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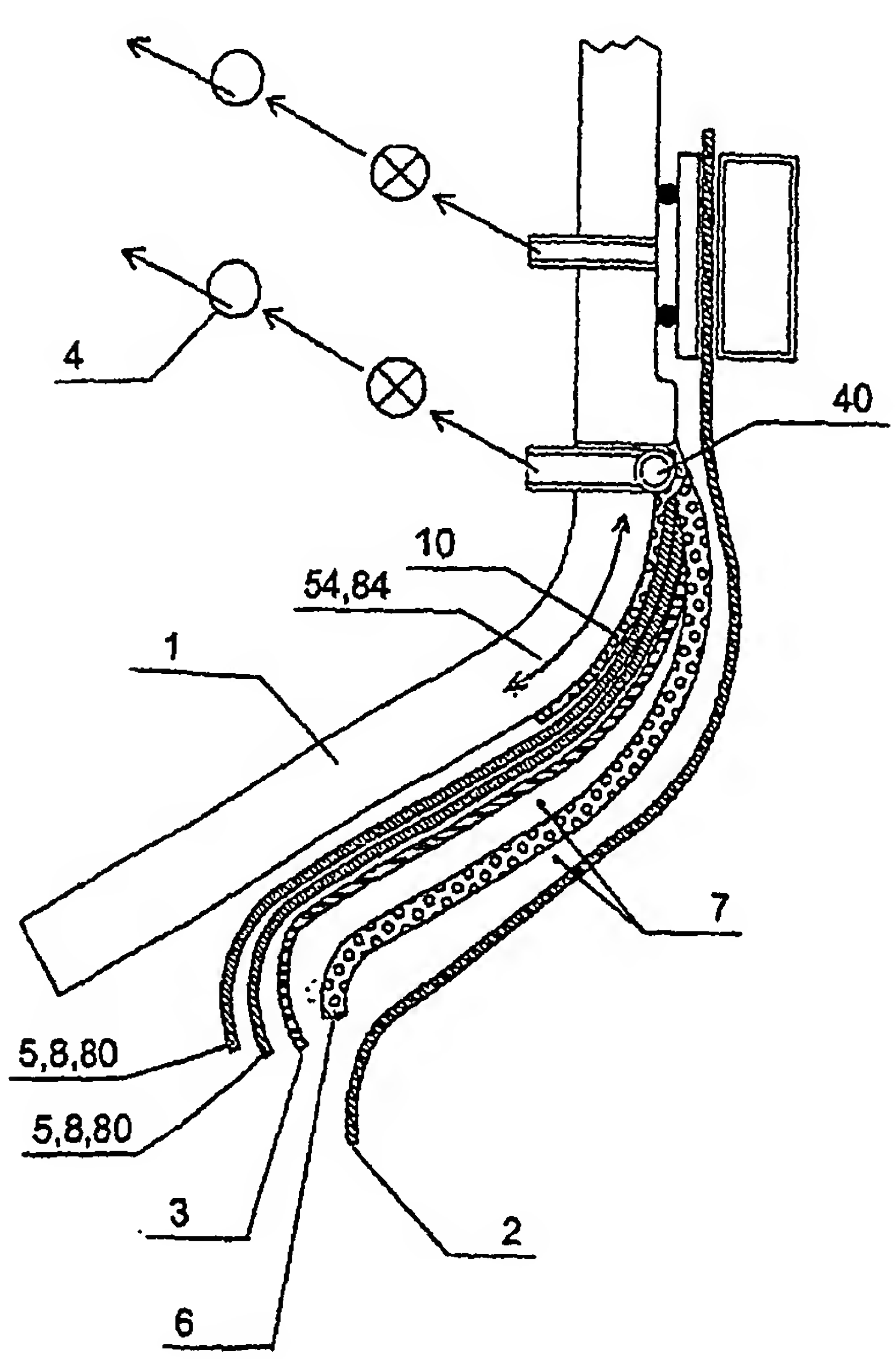

(57) Abstract: The invention comprises a vacuum moulding process for composite materials, where an integrated thermoplastic/fibre reinforcement mat (80) is employed, where the thermoplastic (8) may consist of woven fibres (88) together with reinforcement fibre, e.g. glass fibre (87). In this way the need for injecting thermoplastic or tempering plastic in liquid form after vacuum suctioning of the reinforcement mat, is replaced. The problems with uneven distribution of the thermoplastic (8) are therefore substantially reduced. The integrated thermoplastic/reinforcement mat (81) is placed in a mould (1) and covered with a release film (3) and a vacuum bag (2). The vacuum is applied both to the thermoplastic/reinforcement mat (5, 8, 81), as well as in between the release film (3) and the vacuum bag (2). The vacuum is then consolidated before the temperature is increased, until the thermoplastic fibres become liquid at a temperature of (Tp) and envelopes and binds the remaining integrated fibre mat (5).

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PROCEDURE AND DEVICE FOR THE MOULDING OF COMPOSITE MATERIALS

The present application concerns a procedure and devices required for the vacuum moulding of fibre-reinforced composite materials. The invention also comprises a procedure for moulding a vacuum bag, which will be employed at such thermoplastic composite moulding.

The known art

Fibre-reinforced, tempered plastic is elaborately described in the book Jansson, Jan-Fredrik et al., 1979:"Fiberarmerad härdplast", Ingenjörsförlaget, Stockholm.

A well-known method for forming moulds is to make them in steel or other types of metal. Such metal moulds are very durable and well suited for large series of composite moulded parts, for instance for the car industry. Also, in the construction of the ordinary moulds, it is difficult to achieve a surface that will smoothly release the moulded product. In the case of metal moulds, one solution is to polish the inside of the mould.

Composite materials today, have ever increasing applications, from cars, vessels, trains, aeroplanes, windmills and sports and leisure equipment, to footwear, X-ray tables, engine parts, pipes, tanks, etc. The application is mostly based on a requirement for high strength and low weights, with minimal consumption of materials. Such composites are formed in fibre reinforced plastic laminates, where the fibres could be glass, carbon, aramid, etc., while the plastic materials mostly would be polyester, epoxy, vinylester or phenolic resin systems. The fibre component reinforces the laminate after the plastic has been cured, and provides the basis for the strength of the laminate. The function of the plastic is to keep the fibres in place within the geometry of the product, and very often also provides the outer finish of the product, like colour and a smooth surface. Today, composite products are manufactured by means of several application methods and techniques, depending on the size of the series, weight/strength requirements and financial considerations.

Generally, the plastic component must be applied in liquid form to impregnate the fibres. This may be done by means of spraying equipment, application by hand, vacuum injection or pre-impregnating (so-called "prepreg").

In the case of "Prepreg", a pre-impregnated fibre in refrigerated condition is delivered, where the impregnation is semi-stiff, e.g. in a refrigerator container. The refrigerated pre-impregnated fibre mats are then placed in moulds and covered by a vacuum bag. Subsequently, when a state of vacuum has been established, they can be heated to a curing temperature of approx. 80 degrees C and then cooled down to a finished mould of composite material.

One alternative procedure to refrigerated pre-impregnated mats delivered in refrigeration containers to the composite foundry, is to roll the reinforcement fibre foil, i.e. glass fibre mat or carbon fibre mat, in resin liquid at room temperature. Then move the mat to the mould and, finally, position the wet mat into the mould. This procedure is messy, and besides presenting a health risk, it generates gasses and entails a large loss of resin liquid during the process.

An even more primitive procedure for forming a composite material, is to place dry reinforcement fibre directly into the moulds; then adding the resin liquid directly to the glass fibre reinforcement. In a process like this, the air bubbles between the layers of glass fibre reinforcement must be pressed out before each new layer of fibre is being applied.

There are more advanced, well-known procedures for the vacuum moulding of fibre-resin-composite materials, e.g. for moulding small series of ship hulls, superstructures, hatches, and frames. These procedures have been described several places, among them the "Scrimp" methods by DuPont described in the US-patent 5 721 034, US 5 702 663, and US 4 902 215, by the inventor William H. Seemann III. The Scrimp method is carried out by means of vacuum injection of a resin into a reinforcement fibre mat in a mould.
The mould must be coated with a material that ensures easy release. Subsequently the reinforcement fibre mat is placed

into the mould in the desired pattern. A release agent is placed over the fibre mat, on top of that a "breather" mat, and finally a vacuum bag. Vacuum is applied to the mould by means of e.g. a vacuum bag described in the US patent 5 702 663. In this process, polyester is suctioned into the fibre mat. When the polyester has set, the release agent, the breather mat and the vacuum bag can be pulled off the composite material, and the half-finished composite material can be removed from the mould by means of pressure air or mechanical power.

A similar method to scrimp-moulding is a so-called RTM-moulding, where one employs an arrangement of reinforcement fibre inside a bilateral hollow mould. Vacuum is applied into the layer of reinforcement fibre, and when the vacuum level is satisfactory, resin is pressed inside using e.g. 2 bar. In this type of system, it is not easy to achieve an especially large proportion of reinforcement fibre, because the layers of reinforcement fibre,must be permeable for the resin. Besides, it is a problem that if the layers of reinforcement fibre is too dense, there is a risk that the resin, under pressure, will shift the reinforcement fibres away from the resin's pressure injection points.

<u>Disadvantages in relation to the existing techniques</u>

The existing manufacturing processes have many disadvantages, with regard to environmental issues. The plastics which are used are chemicals in liquid form, which contain substances that represent a health risk in the working environment, and which pollute the external environment. This situation requires large investments in ventilation and cleaning equipment. The substances may also cause serious allergy problems for many people. In the curing process, the heat produced can reach ignition temperature, and constitutes a fire hazard if used carelessly.

During the manufacturing process, the number of required tools and equipment constitutes a large consumption of materials, and the equipment often needs to be cleaned with solvents which again represent a health hazard. The

composite product itself has few, if any, areas of employment after its wear life is over, or when it is discarded, because the thermosetting plastics cannot be recycled or used for other purposes. Furthermore, the quality of the laminates is very dependent on the skills of the operator, and the properties of composites based on thermosetting plastics can vary a lot. Quality assurance of the moulding process requires careful training, thoroughly established procedures, frequent inspections, as well as testing of the finished products, raw materials and process parameters, such as air humidity and temperatures.

<u>Solutions to the above described problems</u>

New fibre technology has made it possible to manufacture hybrid yarn, which is made up of two or more different fibre filaments. Several methods are used to produce this hybrid yarn, among others by means of texturing machines for yarn. This type of yarn has a good mixture of the different material components, which is an important premise for using this commingled yarn in the composite production. In most cases one would mix the thermoplastic fibre with glass fibre, or thermoplastic fibre with carbon fibre. By weaving, knitting or making felt of this yarn ("postpreg"), fibre reinforcements in rolls can be produced according to required configurations and specifications (within the given limitations of machines and equipment). From such fibre reinforcements, it is possible to produce e.g. glass fibre reinforced composite laminates with thermoplastic matrix. This is done by placing fibre reinforcements in a mould in as many layers and in the desired fibre directions required for the product to be dimensioned for the design loads.
This composite laminate achieves strength properties on a level with the best types of reinforced thermosetting plastics. Then, one or more layers with different functions (release, breather, vacuum, etc.) are arranged over the reinforcements in the mould, so that the reinforcements are pressed together when the vacuum pressure is formed on the fibre layers. Under this pressure, the mould containing

reinforcements and foil is heated up to the consolidation temperature, by means of e.g. convection heat from a burner, or from infrared heat (IR). The thermoplastic fibres will melt and form a matrix for the glass fibres (or other strength carrying fibres), with no air pockets. When the entire layer of reinforcement has reached the consolidation temperature, the product is finished, and after a cooling period, can be removed from the mould ready for further refining. Based on this manufacturing method it is possible to build products and constructions in sizes which are only limited by moulds and heating systems, and which can replace the manufacturing processes that are based on thermosetting plastics.

One existing application of this type of glass fibre reinforced thermoplastic mat, is pressure moulding, e.g. in the case of combat helmets. Here a partially heated (partially softened) pre-consolidated sheet is placed in the hollow of a helmet mould, then pressed into the mould by a "head"-mould, using more than 50 Bar pressure. This method, for units in the size of a small boat, would require unwieldy, large, and prohibitively expensive moulds and frames.

This invention concerns a vacuum-baking process for moulding composite fibre materials, where there is no need for vacuum-injection of resin into the fibre mat. The invention comprises a disposable breather. Furthermore, the invention comprises a vacuum bag with integrated vacuum canals. In an alternative design, the invention comprises a so-called release film with integrated vacuum canals. Additionally, the invention comprises flange arrangements, vacuum seal, vacuum bags and accessory elements. The invention also comprises a procedure for making a ceramic mould for casting fibre composite materials. The invention furthermore comprises alternative procedures for making moulds for the purpose of casting fibre composite materials by means of thermal spraying of sintered metal on a model which is a copy of the product.

A short summary of the invention

The invention presented here, comprises in its simplest embodiment a method or process for manufacturing fibre reinforced composite materials with thermoplastic material devised to form a matrix intended for filling and binding a fibre reinforcement in a mould, by the following steps:

Placing a fibre reinforced mat in the mould, where the fibre reinforced mat consist of the fibre reinforcement and an integrated thermoplastic material, which at room temperature is solidified and which is designed to become plastic at an elevated temperature Tp ;

Placing a vacuum bag over the fibre reinforced mat;

- Evacuating air from the fibre reinforced mat by means of a vacuum application arrangement;

Heating of at least the thermoplastic material by means of heat devices, until the thermoplastic material reaches the temperature Tp and envelops the present reinforcement fibres; and

that the fibre reinforced mat with thermoplastic and fibre reinforcement is cooled, until the thermoplastic solidifies and binds the reinforcement fibres, forming a composite material laminate, that the vacuum is released; that the vacuum bag is removed from the composite material laminate, and that the composite material is removed from the mould.

In a preferred embodiment of the invention, the methode for manufacturing fibre reinforced composite material laminates, comprises the following steps:

To form a mould from a model;

To place fibre reinforcement into the mould, where the fibre reinforcement will be part of the finished composite material laminate;

To place a release sheet over the fibre reinforcement;

To place a "breather"-layer for the purpose of leading air out between the release sheet and a vacuum bag, as well as from the fibre reinforcement;

To place the vacuum bag over the "breather"-layer;

To use vacuum suction devices to evacuate air from the fibre reinforcement, as well as from the "breather"-layer;

To use a thermoplastic material designed to constitute

a matrix, for the purpose of filling and binding the fibre reinforcement.

To use a fibre reinforced mat including the fibre reinforcement, with integrated thermoplastic material, which at room temperature is solidified and which is designed to become plastic at a rise in temperature to Tp ;

To use a fluid-proof release film between the fibre reinforced mat and the "breather"-layer;

using vacuum suction from both sides of the fluid-proof release agent, both from the thermoplastic/fibre reinforcement mat, and from the "breather"-layer under the vacuum bag; that the vacuum is maintained during the per se familiar steps, which include heating of at least the thermoplastic material by means of heat devices, until the thermoplastic material liquefies and envelopes the present reinforcement fibres; and that the layer of thermoplastic and fibre reinforcement are cooled by means of cooling devices, until the thermoplastic solidifies and binds the reinforcement fibres, forming a composite material laminate; that the vacuum is released. The vacuum bag, the "breather"-mat and release film are removed from the composite material, and the composite material laminate is removed from the mould.

The invention also comprises a vacuum bag, for moulding composite material against a mould, with a flange and a flange surface. The vacuum bag has a surface cast in the same mould, a vacuum seal system with a surface designed to fit the flange surface in the mould, and where the new vacuum bag and the seal system are made up of one and the same integrated moulded element.

The invention furthermore comprises a moulding profile for casting a seal system for a vacuum bag, which is designed to fit against the flange surface of the mould, comprising;

an underside designed to fit against the flange surface, a top area designed to form a contact surface in the seal system, and a (first) inner longitudinal groove in the top surface, designed to form a (first) inner seal profile (143), as an integrated elevation in the contact surface,

and to form a vacuum canal inside the first inner seal profile.

The invention also comprises a procedure to form a vacuum bag with a vacuum seal system where the contact surface is designed to fit against a flange surface of a flange on a mould, which is designed for moulding composite materials, and comprising the following steps:

To place a profile on the flange surface of the mould; the profile being designed to serve as a mould for casting the surface of the moulded vacuum seal system. The profile has a top area, a (first) inner longitudinal groove in the top area, designed to form a (first) inner seal profile as an elevation in the contact surface, and to form a vacuum canal within the first inner seal profile;

Pouring preferentially liquid, vacuum-bag forming material into the groove, on to the top area and into the mould, thus forming an integrated vacuum bag which completely covers the moulding area of the mould as well as the flange area;

Curing of the integrated vacuum bag including the vacuum seal system in a per se familiar manner, until the vacuum bag has reached the tensile strength and/or mechanical strength sufficient to release it from the mould.

Further aspects of the invention will be evident in the subclaims.

Advantages achieved by this invention

Composite products, which are manufactured by means of vacuum baking fibre reinforced thermoplastic laminates by using this method, have none of the environmental problems suffered by the thermosetting plastic production. They do not produce gasses during manufacturing, require no hand tools or equipment which need cleaning, do not emit dust when being handled, represent no fire hazard, and the materials may be recycled after being discarded. Another significant advantage, is that fibre reinforced thermoplastic laminates, by means of vacuum and heat, can be formed after the laminate is consolidated. This presents the possibility for pre-fabrication of laminates, and

manufacturing of the finished product with in-house post-moulding machines and equipment. The result is a process that ensures considerable financial advantages by reducing the cycle time considerably. The laminates will have a much better quality, because the fibre and plastic component are mixed in advance, and the consolidation is not dependent on the skills of the operators. The manufacturing process is dependent on materials, tools and procedures which ensures that the component has the required finish and properties, that the vacuum is satisfactory, and that they can withstand the process temperatures which are required to ensure that the consolidation is carried out throughout the laminate.

Short description of the drawings

Fig. 1a is a survey layout of composite moulding, by means of the existing technique. It illustrates a section of a mould together with the layer arrangement of the necessary materials, mats and vacuum devices which are part of the ordinary process, where resin is vacuum injected into the glass fibre reinforcement when vacuum has been applied.

Fig. 1b illustrates a sectional drawing of a part of a mould, with the division, layer by layer, of materials and air canals that form part of a moulding process, according to a preferred embodiment of the invention.

Fig. 2 is a principle sketch of moulds formed by, a: thermal spraying on a model or a template; b: a ceramic mould, formed on a model; c: a "numerical" thin sheet mould, based on a numerical model of the desired form of the composite material laminate which is to be manufactured.

Fig. 3 illustrates a mould in sections, placed in a frame with flexible holders for the mould.

Fig. 4a illustrates an oven for placing the frame with the mould in, according to the invention.

Fig. 4b illustrates a frame with a heating device with infrared heating lamps, for melting the matrix material in

the fibre reinforcement which has been placed in the oven. Fig. 5a illustrates a cooling device with air nozzles, for cooling the melted composite material in the mould.

Fig. 5b illustrates cooling canals according to the invention, which are designed to cool the melted composite material in the mould.

Fig. 6a illustrates a section of a mould with release coating according to the invention; with an arrangement of colour/ structure film and a fibre reinforcement/thermoplastic mat according to a preferred embodiment in the invention.

Fig. 6b1 and 6b2 illustrate in sections a mould with release coating, and the spraying of a top coat system directly into the mould before inserting fibre reinforcement/thermoplastic mat, according to a preferred procedure in the invention.

Fig. 7a illustrates a section of a pre-moulded fibre reinforced thermoplastic composite element. Fig. 7b illustrates the heating of, and the placing of the thermoplastic composite element over a secondary mould, e.g. by means of vacuum. Fig. 7c illustrates the resulting remoulded thermoplastic composite element.

Fig. 8a illustrates in sections the splicing or welding of thermoplastic composites by means of heating device.

Fig. 8b illustrates in sections the splicing or welding of thermoplastic composites by means of an ultrasound heating device.

Fig. 8c illustrates in sections the welding of a thermoplastic composite element to another thermoplastic composite element by means of a heating device and a welding rod containing thermoplastic material.

Fig. 9a illustrates an alternative preferred embodiment of the invention, with integrated vacuum canals on the underside of the vacuum bag, so that the breather mat is somehow integrated with the vacuum bag.

Fig. 9b illustrates an alternative preferred embodiment of the invention, comprising a separate breather mat between the release film and the vacuum bag.

Fig. 9c illustrates an alternative preferred embodiment

of the invention, comprising an integrated breather/slip mat under the vacuum bag.

Fig. 10 illustrates a summary of the procedures of the process, according to the invention.

Fig. 11 illustrates a section of a mould and its flange, as well as a vacuum bag; according to the invention with an integrated vacuum seal system, together with devices for forming a vacuum bag such as this.

Fig. 12 illustrates a section of the flange area of a mould, according to the invention designed to form a vacuum bag with integrated seal flange.

Fig. 12b illustrates how a moulding list can be spliced before the vacuum bag seal is formed.

Fig. 13 illustrates a section of a mould with the vacuum bag according to the invention, into which have been placed materials for moulding a fibre composite, and where the vacuum bag has been placed tightly against the composite materials and the flange of the mould.

<u>Description of preferred procedures of the invention</u>

One preferred embodiment of the invention comprises a moulding process for fibre reinforced composite material elements. Reference is made to fig. 1b regarding the description following below. The following steps and remedies are included in the moulding process: A single sided mould 1 is formed, preferably coated with a release layer 30, further described below. In a preferred embodiment, vacuum devices are used, comprising a vacuum bag 2, a release film 3 and vacuum suction devices 4 for evacuating air from a fibre reinforcement 5. In addition, a breather layer 6, guiding the air 7 out between the release film 3 and the vacuum bag 2, and a matrix 8, designed to fill the fibre reinforcement 5. The new aspects of the process comprise the following aspects:

* In the moulding process, a per se familiar fibre reinforced mat 5 with integrated thermoplastic material 8, which at room temperature is solid, but designed to become plastic at an increased temperature Tp.
* -that the release film 3 is essentially fluid proof

between the fibre reinforcement 5 and the breather layer 6. This is advantageous in as far as the thermoplastic material 8 does not spread into the breather layer 6 when the thermoplastic material 8 melts. With that, it is ensured that the finished composite material laminate 9 achieves the correct density and distribution of the thermoplastic material 8, and that uneven thickness, resin or reinforcement fibre 5 dominating are avoided.

The fluid-proof release sheet 3 must be sufficiently elastic to avoid a lack of flexibility in the composite material arrangement, primarily to prevent so-called "bridge-forming" in sharp nooks and corners, where the fibre reinforced thermoplastic mat 5,8,80 could be difficult to pull towards the mould 1, using just vacuum suction. To overcome this, one could apply a certain overpressure outside the thermoplastic mat to press the fibre reinforced thermoplastic mat 5,8,80 against the mould 1.

* -that air is evacuated and that vacuum is formed from both sides of the tight release sheet 3, i.e. both from the thermoplastic/fibre reinforcement mat 5,8 and from the breather layer 6 under the vacuum bag 2, and that the vacuum is consolidated.

* - that the thermoplastic/fibre reinforcement mat 5,8, in a per se familiar manner, is heated up by means of heating devices 16, until the thermoplastic fibres 8 become liquid and envelopes the reinforcement fibres 5.

* - that the layer of thermoplastic 8 and fibre reinforcement 5, in a per se familiar manner, is cooled until the thermoplastic 8 solidifies and binds the enveloped reinforcement fibres 5, forming a solid thermoplastic-filled fibre reinforced composite material element 9.

* - that the vacuum, in a per se familiar way, is released; that vacuum bag 2/breather mat 6 and release sheet 3 are removed from the composite material 9, and the solid thermoplastic-filled fibre reinforced composite material element 9 is removed from the mould 1 for possible further cooling, by means of cooling devices 17, until it reaches room temperature. It is now ready for further refinement.

During tests, the inventors have discovered that 70% of

the vacuum pump capacity should be advantageously employed to evacuate the breather layer 6. The remaining 30% of the vacuum pump capacity should be employed to evacuate air from the layer of thermoplastic/fibre reinforcement 8,5.

This distribution of vacuum pump capacity will ensure a fast and safe vacuum formation and fixation of the thermoplastic /fibre reinforcement 8,5, as well as the vacuum bag arrangements 2,3,6 for the mould 1.

Normally, there is a risk of mobilise a little thermoplastic mass 83 near the outlet 40 for vacuum. According to a preferred embodiment of the invention, a disposable breather 10 has been arranged, designed to be fitted during the instalment of the reinforced thermoplastic /reinforcement fibre mat 8,5. The fitting must be carried out before the heating phase of the moulding process, under the vacuum bag 2, in the areas 54,84 of the thermoplastic/reinforcement fibre mat 5,8, near the outlets 40, against the vacuum suction devices 4, see fig. 1b. The disposable breather 10 is adapted for draining and absorbing any surplus thermoplastic material 83 turning mobile and moving towards the vacuum outlet 40 during melting. The requirements for the disposable breather 10 are that it must stay porous under the kind of pressure which is produced by the vacuum bag during vacuum, and that it can tolerate the temperatures which the thermoplastic will be exposed to during the at melting process.

In an alternative preferred embodiment of the invention, the disposable breather can be held against the mould and the vacuum suction devices 4,40 by means of suction, during the positioning of fibre reinforcement.

Fig. 1b further illustrates that in the moulding process an integrated thermoplastic/fibre reinforced mat can be used, with reference number 80, and also with the reference numbers 8,5, where thermoplastic material 8 is integrated in solid form in the fibre reinforcement 5. The thermoplastic material is, preferably in filament or fibres 88, adapted to become plastic at an increased temperature Tp

over approx. 200°C, e.g. a thermoplastic/glass fibre mat 81 or a thermoplastic/carbon fibre mat 82;

Fig. 2c illustrates one of the alternative preferred embodiments of the invention's moulding process, where a mould 1 is employed, designed as a so-called numerically manufactured thin plate mould 11, from a numerical model of one side of the required composite material element. An alternative to a numerically manufactured thin plate is a hydro formed thin plate, hydraulically pressed into an existing thick, strong master metal -form, which is expensive and unnecessarily demanding.

Fig. 2b illustrates another of the preferred embodiments of the moulding process, according to the invention, where a mould 1 is used, which is designed as a ceramic mould 12 from a template or model, reference number "0", of one side of the desired composite material. A mould like this may be manufactured from ceramic mortar, for instance the ceramic mortar which is used for building moulds for metal melting pots. Ceramic material could include ferro silicone, silicone carbide, silicone dioxide and/or may be mixed with other oxides and/or with sand and/or conducting metal powder. One disadvantage in connection with these ceramic moulds is that they are brittle and endure little mechanical strain. In one embodiment of the invention a separate inner reinforcement is formed in the ceramic mould.

Fig. 2a illustrates a third alternative preferred embodiment of the invention, where a mould 1 is employed, which is designed as a thermally sprayed mould 13, by means of sintered metal against a template or model "0" of one side of the desired composite material- element 9. The process of thermal spraying, is carried out by blowing a mixture of sintered metal, using e.g. a nozzle driven by propane gas, on the surface of a template 0, as described in US 5 296 667: (Flame Spray Industries) "High velocity Electric-Arc Spray Apparatus and Method of Forming

Materials".

The thermal spray-moulding may be carried out by means of metals, which, in the case of thermal spraying techniques using high-voltage electric arc or powder spraying with inflammable gas, are moulded around the template 0. The template has been treated with a release agent to assure a non-sticky surface between the template and the mould 1. A numerical thin plate mould 11 will normally be too weak to be used without a support frame. A ceramic mould 12 and a thermally sprayed mould 13 will both normally be too brittle to be used without a support frame. A support frame, which can satisfactorily hold at least the three different types of mould, is frame 15 as illustrated in fig. 3. The frame 15 is supporting the mould 1,11,12,13, preferably with flexible support devices 14, which are designed to absorb some of the thermal form changes or tensions which may arise during heating and cooling in the moulding process. In that way one avoids bending and/or brittle fractures caused by the weight of the frame itself, as well as the weight of the thermoplastic /fibre reinforcement mats 80. One must also consider the weight of the vacuum bag 2, the breather mat 6 and the release film 3, and any vacuum hoses and vacuum frames, which also weighs upon the mould 1.

In the familiar techniques, it is normal that metal moulds are polished to ensure easy release of the composite material laminate 9, and to ensure a perfectly smooth surface. To polish the mould is a very expensive and complicated process, which should only be allowed for very large manufacturing series. According to a preferred embodiment of the invention, schematically illustrated in fig. 3 and fig. 6, the mould 1,11,12,13 is coated with a permanent release layer 30 in the form of polytetrafluor ethylene 30, also called PTFE or "Teflon", or an equivalent material for the release layer 30.

In a preferred embodiment of the invention, the mould 1,11,12,13 and preferable the release layer 30, is coated with a colour topcoat or structure layer 32. This layer is

able to adhere to the thermoplastic/fibre reinforcement mats 80; to the fibre reinforcement 5; or to the thermoplastic material 8, in order to form an integrated coloured top layer or structured surface of the finished composite material laminate 9.

An alternative embodiment of the invention may be carried out as shown in fig. 6a, by coating the mould 1,11,12,13, and preferentially the release layer 30, with a film, foil, textile (felt or woven or knitted) or a membrane, comprising the colour or structure layer 32. Another alternative embodiment of the invention may be carried out as shown in fig. 6b and 6c, by spray coating the mould 1,11,12,13, and preferably the release layer 30, with a spray nozzle 34, or painting it with the colour or structure layer 32. The colour or structure layer 32 can be composed of a powder or granulate which adheres to the surface of the mould by means of heat, electric fields or with adhesive agents, and can comprise materials which can melt to give the desired colour and finish. A colour agent like this can comprise acrylic colour, coloured thermoplastic, transparent varnish powder, coloured polyester, or epoxy. It is also possible to use a colour pigment agent mixed with a binding agent. A colour agent base 32, which is sprayed on by means of electrostatics, and where the colour agent and the mould have been given opposite electrical charges during the spraying process, will be mechanically weak. It would scratch easily, and even risk being swept off the mould when adding the next layer of the moulding process, which will consist of fibre material. In one embodiment of the invention, the colour agent layer 32 may be partially melted by means of heat before any further lay-up is carried out. In this way, the colour agent 32 will achieve the structural strength required to endure further addition of the thermoplastic/fibre reinforcement mat 8,5,80.

The heating of the thermoplastic/fibre reinforcement mat 8,5,80 can be carried out in various ways. It is important that the heating of the thermoplastic material 8 is carried out gradually, so that essentially all of it reaches the melting temperature simultaneously and that as little as

possible of the thermoplastic material 8 becomes of too low viscosity. The viscosity changes over a certain span of temperature. However, employing a completely fluid proof release film 3, according to a preferred embodiment of the invention, the problem with the mobilisation of the thermoplastic material 8, is practically eliminated. Any possible mobilised melted thermoplastic material could entail a problem, which generally can be isolated to the areas 54,84 around the vacuum suction 40, where the local disposable breather 10 drains any mobilised melted surplus thermoplastic mass. In a preferred embodiment of the disposable breather 10, it has been given an incollapsing design, of for instance glass wool, to ensure that it does not collapse during the vacuum pressure load. The heating of the thermoplastic/fibre reinforcement mat 8,5,80, can be carried out by means of heating devices 16 inside a closed oven 20, see fig, 4a, preferably using hot air fans 21 to distribute the heat energy. One advantage of using this type of closed oven, is that a good distribution of heat is achieved, thereby achieving an overall simultaneous melting of the thermoplastic material 8. In the design of the present invention, it is possible to achieve more than 60-80% fibre reinforcement 5 of the total weight of the composite material element 9.

The reason for this is that there is no longer required that the reinforcement fibre bearing mat 5,8,80 is permeable to the melted thermoplastic 8, as this is basically already located near its intended place between and around the reinforcement fibres. One alternative could be to employ microwaves for selective heating of the relatively small amount of thermoplastic material 8, in order to save energy in not directly heating other elements in the process. e.g. the fibre reinforcement 5, the mould 1, or the accessory mats, which all can have a chemical compound that is totally different from the thermoplastic material.

In an alternative preferred embodiment of the invention, the heating of the thermoplastic/(fibre reinforcement)- mat 8,(5), 80, is carried out by means of heating devices 16, comprising heat lamps 22, preferably with infrared radiation

as illustrated in fig. 4b. One advantage achieved by employing heat lamps 22, is that the heat is more localised, and to a less extensive volume than the volume which is heated in a closed oven. Clearly it is not necessary to heat for instance, the frame 15 to melt the thermoplastic material 8 in the thermoplastic/fibre reinforcement mat 80. An alternative type of heating lamp 22, could be a microwave radiating device, which in a wavelength adjusted design essentially only heats up the thermoplastic material 8, and which does not heat up the reinforcement fibre 5 and the mould 1. The advantage of employing heat lamps is that the process can be carried out faster, by eliminating the transport of the mat covered mould between the laying-up station and the oven.

When the thermoplastic material has melted and enveloped the reinforcement fibres 5, "5,8" now constitutes a composite material element 9, which for various reasons needs to be cooled quickly; homogeneity of the thermoplastic material, and to prevent crystallisation of the thermoplastic material. Also, to be able to carry out a quick production process with low cycle time per processed composite material element 9.

In a preferred embodiment of the invention, the cooling of the thermoplastic /(fibre reinforcement) mat 80, which has now become a composite material element 9 as illustrated in fig. 5a, is carried out by means of cooling devices 17. These devices comprise several cold air nozzles 171, which are spread all over the fibre reinforced thermoplastic lay-up 5,8,80, and also over the backside of the mould 1, in order to achieve a two-sided cooling. One alternative, or supplementary, cooling method, is to accomplish the cooling of the composite material element 9, illustrated in fig. 5b, by means of the cooling devices 17, comprising cooling tubes or cooling canals (or heating canals) 172, which are integrated in the mould 1 and adapted for circulating cooling agents (cooling gas or cooling liquids like air, water or oil-based agents)173. The same cooling canals 172 may also be employed as heating canals 172 when the mould is heated to melt the thermoplastic material 8, as described

above. The integrated cooling canals 172 in the mould 1, can be formed by means of materials like wax or plastic or metal rods, which will melt at a lower temperature than the mould 1, thus creating the cooling canals when the fusible materials melt is tapped or drained out. Dielectric high-frequency fields can be used for heating the thermoplastic material.

The post-moulding of the finished composite material 9 is illustrated in fig. 7. The post-moulding is carried out, by heating up the composite material element 9 comprehensively, or locally, by means of a heating device 16', until a local softening occurs.
The composite material element 9 can then be pulled and adjusted to form, by means of vacuum suction devices 4' over a mould 1', with subsequent new active or passive cooling to ensure that the re-moulded composite material element 9' is solidified/tempered.
One way of preparing for such post-moulding, is to make a reinforcement which is adjusted by a tighter or skimpier laying-up of the fibre reinforcement 5 in the areas intended for post-moulding. This should already be done at the start, when the thermoplastic /fibre reinforcement mat 5,8,80 is positioned in the mould 1.
Also the orientation of the fibre reinforcement 5 can be adjusted for this type of post-moulding. This way, a smooth and adjusted reinforcement is achieved, even where it is pulled over the edges and corners of the post-moulded composite material element 9.

In the known art, separate release agents, breather mats and vacuum bags are illustrated. In a preferred embodiment of the invention, as illustrated in fig. 9, a vacuum bag 2 is employed, with a connected network of furrows which make up the integrated vacuum canals 26, on the underside of the vacuum bag. The integrated vacuum canals 26, can be used because of the presence of the seal release film 3 which will ensure that there is no danger of leaking from melting or surplus thermoplastic mass 83 through the release film 3, and the breather mat 6 could therefore become unnecessary. It is possible to use a silicon based vacuum mat 2 and

release film 3 which is produced by spray moulding in the designed mould 1, or on the model 0 which shall be used to achieve the exact geometry. It is possible to reinforce the vacuum bag 2 and the release film 3, by means of a separate fibre reinforcement of glass, metals or plaster for large constructions. The vacuum bag 2 can be moulded on separate fibre reinforcements to form the vacuum canals 26 in the surface, for the purpose of vacuum distribution, where these fibre reinforcements are made of PTFE or similar, to release the foil after spraying. In an alternative embodiment of the invention, the ordinary lay-up is employed, using separate breather mat 6 between the release film 3 and the vacuum bag 2, as illustrated in fig. 9b.
However, it differs significantly from the known technique by the fact that the release film is designed to work as a seal.

To provide heating for the melting and cooling of the thermoplastic, the vacuum bag itself can be equipped with heating and cooling devices, for instance canals 172′ for circulating the cooling or heating liquids 173′, which could be identical to the cooling or heating liquid 173. For the purpose of heating the vacuum bag, electrical conductors 172″ can be applied.

In an alternative preferred embodiment of the invention, an integrated breather / release layer 6,3 under the vacuum bag is employed, as illustrated in fig. 9c.
The flange arrangements in the moulds, as well as the attachment devices for the various mats and layers to be attached to the profiles or vacuum pipes, and/or attached under clamp seals for the vacuum bag, are only outlined in fig. 1b, but described more in detail below, in connection with fig. 11, 12 and 13.

Some steps of the schematic summary of the process procedure, according to the invention, are outlined in fig. 10.

* A model is produced of the product to be manufactured.
* A mould is built on the model, made of material suitable for heating; e.g. ceramic, or metal based, or

from other types of material.

* A release agent is applied to the mould, based on temperature resistant wax, or chemically based agents, or permanent release film, preferably teflon.

* The mould is built complete with reinforcements, flange arrangements, vacuum pipes, couplings and seals for release films.

* Vacuum foils, vacuum distribution layers and release film are prepared and adjusted to fit the mould.

* A material, which will provide the finished composite laminate with the required surface, is prepared and applied to the mould.

* An integrated fibre reinforcement, based on hybrid yarn with a mixture of thermoplastic fibre and reinforcement fibre, e.g. glass fibre, is cut and adjusted to fit the mould before it is positioned into the mould.

* The fibre reinforcement can be attached to and hung in the mould in the vacuum distribution layer along the edges, or attached to separate profiles which are integrated in the mould.

* Release film and foil/mat/reinforcement mat for vacuum distribution (breather) and vacuum foil, are positioned over the hybrid fibre reinforcements and attached to the mould.

* The mould is connected to the vacuum installation and vacuum is applied until a minimum of 85-90% vacuum has been achieved. Pressure sensors are placed on critical spots in the mould.

* Under vacuum, the whole mould and materials are placed in an electric or gas fuelled oven, which can be pre-heated, or exposed to IR heat from suitable IR lamps.

* Under consolidated vacuum, the whole laminate is heated until the melting temperature of the thermoplastic has been reached for a certain amount of time, in all parts of the mould and in all layers. This can be verified by means of temperature control, achieved by sensors placed in critical areas in the

mould and in the material.

* When the correct temperature has been reached over a certain amount of time, the heating process is terminated and the mould is cooled down, either naturally or by induced cooling. The vacuum pressure is maintained until the laminate has the correct temperature required, to maintain the consolidation.

* When the temperature is sufficiently low, the vacuum foil, distribution layer and release layer are removed from the mould, to allow the composite material element to cool down to room temperature.

* When the laminate has cooled down, the completed composite material element is removed from the mould. It is now ready for further treatment in the form of rubbing, edge cutting, polishing, spray-painting and other forms of finishing, like mounting.

Description of preferred embodiments of vacuum bag and flange seal

Fig.11 illustrates a section of a mould and its flange, as well as a vacuum bag according to the invention with integrated flange seal, and the arrangements required for moulding such a vacuum bag.

Fig. 12 illustrates a section of the flange area of a mould according to the invention, designed to form a vacuum bag with integrated flange seal.

Fig. 13 illustrates a section of the mould with the vacuum bag according to the invention, where materials for moulding a fibre composite have been placed, and where the vacuum bag has been placed tight as a seal against composite materials and the flange of the mould.

Fig. 11 illustrates a vacuum bag 2 for moulding composite materials 9, against a mould 1 with a flange 110 with a flange surface 111, where the vacuum bag has a moulded surface 2f and a flange seal 120 with a surface 121 arranged to fit the flange surface 111. The new idea according to the invention, is that the vacuum bag 2 and the flange seal 120, is made up of one

and the same integrated moulded piece 158.

According to a preferred embodiment of the invention, the integrated vacuum bag 2 and the flange seal 120 are formed by one heat resistant and elastic material, which regains its form after stretching, preferably silicon.

This ensures that the vacuum bag can endure the mechanical strain caused by the external pressure during vacuum forming, and when the vacuum bag 2,158 is pulled off or pressure-blown off when the composite material is removed after the moulding has been completed.

According to a preferred embodiment of the invention, a first, internal seal 143 has been formed. This is made up of an integrated elevation in the same piece of moulded vacuum bag 2,158, arranged along the surface 121 of the seal flange 120, designed to close and seal the room between the mould 1 and the vacuum bag 2. A second, outer seal 145, is made up of an integrated elevation 145 outside the first, inner seal 143, arranged along the surface 121, and designed to form and close a hollow space 147. This is formed on the outside of the first inner seal 143, where the hollow space is defined by the surface 121, the first inner seal 143 and the flange surface 111, by means of placing the seal flange 120 against the flange 110 on the mould 1. The outer seal 145 forms a wall in, and closes, a hollow space 147, which is defined by the flange surface 111, the surface 121 of the seal flange 120, and the first,inner seal 143. In that way, using vacuum pumping, vacuum is achieved between the inner seal 143 and the outer seal 145, so that the seal flange 120 is sucked tight to the flange 111.

In a preferred embodiment, illustrated in the figures 11, 12 and 13, a reinforcing profile 114 for the seal flange 120 has been arranged, to function as a brace for the seal flange 114 against the flange surface 111. The stiffening profile 114 for the seal flange 120, has been placed over the inner seal 143, in

order to brace the first, inner seal 143 against the flange surface 111. The reinforcing profile 114 is, in a preferred embodiment, broad enough to also cover the outer, second seal 145, simultaneously bracing the outer, second seal 145.

According to a preferred embodiment of the invention the stiffening profile 114 is positioned, enveloped entirely inside the seal flange 120.

During the formation of the seal flange 120, it would be advantageous to use the reinforcement supports 117, which are designed to support the stiffening profile 114 when the liquid mass is being applied. The reinforcement support 117 should be made up of the same material as the seal flange 120 and the vacuum bag 2.

According to the preferred embodiment of the invention, at least one valve sleeve 141 has been arranged between the first, inner seal 143, and the outer second seal 145, through the seal flange 120. During vacuum pumping, a hose 149 is connected to the valve sleeve 141, in order to pump vacuum between the inner seal 143 and the outer seal 145, so that the seal flange 120 is fastened tightly on to the flange surface 111.

Perforations 115 can be applied to the brace mould 114, designed to form bridges 115' through the stiffening profile 114 of the material 158 seal flange 120, designed to lock the stiffening profile 114 in the seal flange 114.

A vacuum bag 2,158, can, according to the invention, comprise carbon fibre which is added to the liquid seal/vacuum bag mass. Among other things, this will result in the vacuum bag becoming both electrically conducting and heat conductive. The carbon fibre bearing vacuum bag 2,158 can in this way be grounded to the mould or a common electric earth conductor. By so doing, two advantages have been gained: One avoids the build up of undesired electric charge in the vacuum bag, which constitutes a big problem for personnel working with the vacuum bag, especially when pulling

the vacuum bag 2,158 off the finished composite material 9. The second advantage is that the vacuum bag 2,158 achieves a better heat conducting property, thus obtaining a better distribution of heating and quicker cooling of the composite material 9.
In an alternative embodiment of the invention, only one layer of the vacuum bag 2,158 contains carbon fibre, preferably in towards the mould and "lay-up".

In one embodiment of the invention, integrated canals 172' have been arranged for circulating cooling or heating liquid 173' in the vacuum bag 2, designed for heating or cooling the moulding materials and possibly the mould 1, through the vacuum bag 2. For the purpose of heating the vacuum bag, integrated electrical conductors 172" can be arranged in the vacuum bag 2, which are designed for heating the moulding materials in the mould 1 through the vacuum bag 2.

<u>Profile moulding for casting the seal flange</u>

The invention also comprises, as illustrated in fig. 12, *a profile moulding* 150 *for casting a profiled seal* flange 120 for a vacuum bag 2. The profile moulding 150 has been designed to bear against the flange's 110 flange surface 111 of a mould 1, and has an underside 111', designed to bear against the flange surface 111. It has a top surface 121', which forms a contact surface 121 in the seal flange 120. A first, inner longitudinal groove 143' in the top surface 121' has been designed to form a first, inner seal 143, like an integrated elevation in the contact surface 121, and also to form a vacuum canal 155 within the first inner seal 143. This first inner seal 143, is illustrated in fig. 11, just after the moulding of the integrated vacuum bag 2,158, and is also illustrated in fig. 13 in working position, against a contact surface 11 on the mould's flange 110. The inner seal 143 is made up of an integrated elevation 143 alongside the contact surface 121 of the seal flange 120. The integrated seal, in the

form of the elevation 143, will then essentially receive the same thermal and mechanical properties as those of the integrated vacuum bag 2,158. Additionally, during the work, one will be able to save time, because it will not be necessary to install the seal separately after the composite moulding. The other longitudinal outer groove 145' in the top surface 121, is intended for the forming of a second, outer seal 145, like an elevation in the contact surface 121. The first and the second longitudinal outer furrow 143', 145' on the profile moulding causes the formation of a longitudinal ridge **147'?**, illustrated in fig. 11, which will form the cavity 147' in the contact surface 121.

In a preferred embodiment of the invention, a recessed inner shoulder 154 which is designed to make the created vacuum canal 155 relatively shallow, has been arranged in the profile moulding's 150 top surface.

The profile moulding can be formed by assembling stiffening profiles along the edge of the flange surface 111. Alternatively, it could comprise an extruded or pultruded flexible moulding, designed to be placed on and along the flange surface 111, and also designed to join the two free ends. As a further alternative, it could comprise a stiff or flexible moulded unbroken frame or ring, arranged for being placed on the flange surface 111.

In the case of joining, the profile moulding 150 could include longitudinal recesses at the ends, as illustrated in fig. 12b. The recesses have been arranged to accommodate straight, or in the flange level cracked joints, designed to join the profile moulding in such a way that it adapts to the flange's 110 profile of the mould 1.

According to one embodiment of the invention it is possible, by means of the following procedure, to form a vacuum bag 2 with a seal flange 120, with contact

surface 121, designed to bear against a flange surface 121 on a flange 110 on a mould 1, arranged for moulding composite materials 9 by placing a profile moulding 150 on the mould's 1 flange surface 111, where the profile moulding 150 has been arranged to function as a local mould for moulding the contact surface 121 of the profiled seal flange, where the profile moulding has a top surface 121', a first inner longitudinal groove 143' in the top surface 121', designed to form a first, inner seal 143 as an elevation in the contact surface 121, and to form a vacuum canal 155 within the first inner seal 143. The procedure then is to add a preferably liquid seal/vacuum bag mass 158 into the furrow 143', on the top surface 121' and in the mould 1, so that an integrated vacuum bag 2 is formed, which completely covers the moulding surface and flange surface 111 of the mould 1. After that, the solidifying/ tempering of the integrated vacuum bag, including the seal/vacuum bag mass 158, will start, in an a per se well-known manner, until the vacuum bag 2 has achieved sufficient tensile strength and/or mechanical strength to be released from the mould 1. According to a preferred embodiment of the invention, a heat resistant and elastic material, which will regain its form after stretching, preferably silicon, will be applied for the integrated vacuum bag 2 and the seal flange 120. Before adding the seal/vacuum bag mass 158, a stiffening profile 114 for the seal flange 120, is placed at the desired distance over the profile moulding 150, as described above.

According to an advantageous embodiment of the invention, reinforcement supports 117 are placed on the profile moulding, in such a way that they support the stiffening profile 114 during the formation of the seal flange 120.

The reinforcement supports 117 consist preferably of the same type of material as the seal/vacuum bag mass 158 that will constitute the seal flange 120 and the vacuum bag 2.

The stiffening profile 114 could to advantage be moulded into the seal flange 120 in its entirety. For vacuum pumping, it is possible to pump vacuum through a hole in the flange 110 on the mould 1. However, according to the invention, it would be advantageous to place at least one valve sleeve 141 on the profile moulding 150, standing between the first, inner groove 143′ and a second, outer groove 145 in the top surface 121′ of the profile moulding 150.

In the familiar known art, one normally adds a colour or structure layer to surface of the moulded composite material 9, subsequent to the completion of the moulding process itself, for instance by spray coating or painting. This is often both awkward and time consuming. To form an outer layer in a composite material 9 by means of moulding in a mould 1, the invention suggests that the mould 1 and preferably a release layer 30 could be coated with a colour or structure layer 32. During the moulding process these will be included in the finished composite material 9. The colour or structure layer 32, must be able to adhere to the fibre reinforcement 5 or the matrix material 8, and forms an integrated coloured and/or structured surface of the finished composite material 9. According to an advantageous embodiment of the invention, this could be achieved by the electrostatic spraying of a layer of colour agent 32, where the colour agent and the mould 1 is given opposite electrical charges during the spraying process. Several advantages will be achieved in this way, among others the prevention of unwanted distribution of colour agent during the spraying, and that the colour agent is statically connected to the mould. During the period of pre-heating the mould 1, before the layer of colour agent 32 has been sprayed on, the layer of colour agent 32 may be immediately partially melted when it is being applied to the mould a, so that it becomes homogenous and is kept in place. According to a preferred embodiment of the invention, the colour agent layer 32

is cooled down before any of the other materials which are included in the composite material 9, like the matrix material and the fibre reinforcement 8,5,80, are applied.

The vacuum bag 2 is basically intended as a flexible and pliable device, but, as an extreme example, could constitute a more or less solid form, otherwise moulded as described above.

C l a i m s

1. Procedure for manufacturing fibre reinforced composite material elements (9) with thermoplastic material (8), arranged to constitute a matrix that shall fill and bind a fibre reinforcement (5) in a mould (1), comprising the following steps: characterised by

arranging a fibre reinforced mat (80) in the mould (1), where the fibre reinforced mat (80) includes the fibre reinforcement (5) and an integrated thermoplastic material (8), which at room temperature solidifies and which is designed to become plastic at an increased temperature (Tp) ;

arranging a vacuum bag (2) on the outside of the fibre reinforced mat (5,80);

- evacuating air from the fibre reinforced mat (5,80) by means of vacuum suction devices (4);

heating at least the thermoplastic material (8,80) by means of heating devices (16), until the thermoplastic material (8) reaches the temperature (Tp) and envelopes the reinforcement fibres (5); and

that the fibre reinforced mat (80) with thermoplastic (8) and fibre reinforcement (5) is cooled down until the thermoplastic (8) solidifies and binds the reinforcement fibres (5), forming a composite material element (9); that the vacuum is released; that the vacuum bag (2) is removed from the composite material (9), and that the composite material element (9) is removed from the mould (1).

2. Procedure according to claim 1, characterised by arranging a breather layer (6) for guiding air out of the fibre reinforcement (5);

3. Procedure according to claim 3, characterised by arranging a release film or layer (3) over the fibre reinforced mat (80,5,80) before the breather layer (6)

is added; and

vacuum suctioning from both sides of the release agent (3), both from the thermoplastic/fibre reinforcement mat (5,8,80) and from the breather layer (6) under the vacuum bag (2), and that the vacuum is maintained during the heating process;

4. Procedure according to claim 3, characterised by the employment of a fluid proof release film (3).

5. Procedure according to claim 1, characterised by actively cooling down the thermoplastic layer (8) and the fibre reinforcement (5) after the heating process, by means of cooling devices (17), until the thermoplastic (8) solidifies and binds the reinforcement fibres (5).

6. Procedure according to claim 1, characterised by the placement of a disposable breather (10), prior to the heating phase of the moulding process, under the vacuum bag (2) in the areas (54,84) of the thermoplastic/fibre reinforcement mat (5,8), near the outlet (40) towards the vacuum suction devices (4), for the purpose of draining and absorbing possible surplus thermoplastic mass (83) turning mobile and wandering towards the vacuum outlet (40) during the thermoplastic's (8) melting process.

7. Procedure according to claim 1, characterised by the employment of a fibre reinforced mat (80), where the thermoplastic material (8) is integrated, preferably as filaments or fibres (88), designed to become plastic or melt at an increased temperature (Tp) above approx. 200°C, e.g. a thermoplastic/glass fibre mat (81) or a thermoplastic/carbon fibre mat (82);

8. Procedure according to claim 1, characterised by the employment of a mould (1) formed as a numerically manufactured thin plate form (11) from a numerical

model of one side of the desired composite material element (9).

9. Procedure according to claim 1, characterised by the employment of a mould (1,12) formed in ceramic material (12) of a template or model (0) of one side of the desired composite material element (9);

10. Procedure according to claim 1, characterised by the employment of a mould (1), formed as a thermally sprayed mould (13) from a template or model (10) of one side of the desired composite material element (9).

11. Procedure according to claim 1, 8, 9 or 10, charactirised by the employment of a frame (15) which holds the mould (1,11,12,13), preferably by means of flexible holding devices (14), designed to absorb part of the thermal form changes or tensions that may arise during the heating and cooling period of the moulding process.

12. Procedure according to one of the claims 1, 8-11, characterised in that the mould (1, 11,12,13) is coated with a permanent release layer (30) in the form of polytetrafluor ethylene, PTFE "Teflon" or equivalent.

13. Procedure according to one of the claims 1, 8-12, characterised in that the mould (1, 11,12,13) and preferably the release layer (30) is coated with a colour or structure layer (32) with the ability to adhere tot he fibre reinforcement (5) or the thermoplastic material (8) for the purpose of forming an integrated coloured and/or structured surface of the finished composite material element (9).

14. Procedure according to claim 13, characterised by the electrostatic spraying of a colour agent (32), where the colour agent and the mould (1, 11, 12, 13)

are given opposite electrical charges during the spraying process.

15. Procedure according to claim 13, characterised by pre-heating the mould (1, 11, 12, 13) before spraying on the colour agent layer (32) so that the colour agent layer (32) is partially melted immediately after being applied to the mould (1, 11, 12, 13).

16. Procedure according to claim 13, characterised by the cooling down of the colour agent layer (32) before commencing to add thermoplastic/fibre reinforcement mat (8,5,80).

17. Procedure according to claim 13, characterised by that the colour agent layer (32) is partially melted by means of heat, and then preferably cooled down before adding the thermoplastic/fibre reinforcement mat (8,5,80).

18. Procedure according to claim 13, characterised in that the mould (1, 11,12,13) and preferably the release layer (30) is coated with a film comprising the colour or structure layer (32).

19. Procedure according to claim 13, characterised by that the mould (1, 11,12,13) and preferably the release layer (30) is spray-coated by means of a spray nozzle (34) or painted with the colour or structure layer (32).

20. Procedure according to claim 1, characterised in that the heating of the thermoplastic/fibre reinforcement mat (8,5) is carried out by means of heat devices (16) inside a closed oven (20), preferably using hot air fans (21) to distribute the heat energy.

21. Procedure according to claim 1, characterised in that the heating of the thermoplastic/fibre

reinforcement mat (8,(5)) is carried out by means of heat devices (16) comprising heat lamps (22), preferably with infrared radiation or microwaves or high frequency dielectric fields.

22. Procedure according to claim 1, characterised in that the cooling down of the thermoplastic/fibre reinforcement mat (8,(5)) or the finished composite material element (9) is carried out by means of cooling devices (17) comprising cold air nozzles (171).

23. Procedure according to one of the claims 8-10, characterised in that the cooling down or heating of the thermoplastic/fibre reinforcement mat (8,5) or the finished composite material element (9) is carried out by means of cooling devices (17) comprising cooling or heating tubes (172) integrated in the mould(1), designed for circulating cooling liquids (cooling gas or cooling liquid) or heat carrying liquids (173).

24. Procedure according to claim 1, characterised by heating or cooling the thermoplastic (8) via the vacuum bag (2) by means of integrated canals 172' for circulating cooling or heating liquid 173' in the vacuum bag (2).

25. Procedure according to claim 1, characterised by the heating of the thermoplastic (8) via vacuum bag (2) by means of integrated electric conductors (172") in the vacuum bag (2).

26. Procedure according to claim 1, characterised in that the post-moulding of the finished composite material element (9) is carried out by a general or local heating of the composite material element (9) by means of a heat device (16') until a local softening occurs, and to pull off the composite material element by means of vacuum suction devices (4') over a mould (1'); and subsequent new cooling down for tempering the

restructured composite material element (9').

27. Procedure according the claim 1, characterised by a vacuum bag (2) with a continuous network of canals or furrows in the vacuum bag (2) which constitute integrated vacuum canals (26) on the side of the vacuum bag (2) that faces the release film (3) and/or the composite material element (5,8,9).

28. Procedure according to claim 1, characterised by an integrated breather/release layer (6,3) in the vacuum bag (2).

29. Vacuum bag (2), for moulding composite materials (9) on a mould (1) with a flange (110) with a flange surface (111), where the vacuum bag has a moulded surface (2f) and seal flange (120) with its contact surface (121) arranged to bear against the flange surface (111), characterised in that the vacuum bag (2) and the seal flange (120), is made up of one and the same integrated moulded piece(158).

30. Vacuum bag according to claim 29, characterised in that the integrated vacuum bag (2) and the seal flange (120) are made of a heat-resistant and elastic material that retains its form after stretching, preferably silicon.

31. Vacuum bag according to claim 29, characterised by a first, inner seal (143) that is made up of an integrated elevation in the same moulded piece (158), arranged along the contact surface (121) of the seal flange, designed to close and seal the room between the mould (1) and the vacuum bag (2).

32. Vacuum bag according to claim 29 or 30, characterised by a second, outer seal (145) that is made up of an integrated elevation (145) on the outside of the first, inner seal (143), arranged along the

contact surface (121), and designed to form and close a cavity (147) which is formed outside of the first, inner seal (143), where the cavity (147) is limited by the contact surface (121), the first, inner seal (143) and the flange surface (111), when assembling the seal flange (120) against the flange (110) on the mould (1).

33. Vacuum bag according to claim 29, 30 or 31, characterised by a stiffening profile (114) for the seal flange (120) designed to brace the seal flange (114) against the flange surface (111).

34. Vacuum bag according to claim 33, characterised by that the stiffening profile (114) for the seal flange (120) is placed over the inner seal (143) and arranged to brace the first, inner seal (143) against the flange surface (111).

35. Vacuum bag according to claim 33 or 34, characterised in that the stiffening profile (114) is placed over the outer, second seal (145) and arranged to brace the outer, second seal (145).

36. Vacuum bag according to one of the claims 33, 34 or 35, characterised in that the stiffening profile (114) is placed in its entirety enveloped inside the seal flange (120).

37. Vacuum bag according to one of the claims 33, 34, 35 or 36, characterised by reinforcement supports (117) designed to carry the stiffening profile (114) during the formation of the seal flange (120), where the reinforcement supports (117) preferably consist of the same type of material as the seal flange (120) and the vacuum bag (2).

38. Vacuum bag according to claim 31, characterised by at least one valve sleeve (141) arranged between the first, inner seal (143) and the outer, second seal

(145), through he seal flange (120).

39. Vacuum bag according to claim 29, characterised by perforations (115) in the stiffening profile (114) designed to form bridges (115') through the stiffening profile (114) of the material (158) the seal flange (120), designed to lock the stiffening profile (114) in the seal flange (114).

40. Vacuum bag according to claim 29 or 30, characterised in that it includes carbon fibre added to the liquid seal/vacuum mat mass (158).

41. Vacuum bag according to claim 29, characterised by integrated canals 172' for circulating cooling or heating liquids 173' in the vacuum bag (2) arranged for heating or cooling the moulding materials and possibly the mould (1) via the vacuum bag (2).

42. Procedure according to claim 1, characterised by integrated electric conductors (172") in the vacuum bag (2), arranged for heating the thermoplastic (8) and possibly the mould (1) via the vacuum bag (2).

43. Profile moulding (150) for casting a profiled seal flange (120) for a vacuum bag (2) designed to bear against the flange surface (111) of the mould's (1) flange (110), characterised by

an underside (111') designed to bear against the flange surface (111);

a top surface (121') designed to form the contact surface (121) of the seal flange (120);

a (first), inner longitudinal groove (143') in the top surface (121'), arranged to form a (first,) inner seal (143) like an integrated elevation in the contact surface (121), and for forming a vacuum canal (155) inside of the first, inner seal (143).

44. Profile moulding (150) according to claim 43,

characterised by a second, longitudinal outer groove (145') in the top surface (121'), arranged to form a second, outer seal (145) as an elevation in the contact surface (121).

45. Profile moulding (150) according to claim 43 or 44, characterised by a recessed inner shoulder (154) in the profile moulding's (150) top surface, arranged to make the moulded vacuum canal (155) shallower.

46. Profile moulding (150) according to claim 43, characterised in that the profile moulding is formed by the assembly of rigid elements along the flange surface (111).

47. Profile moulding (150) according to claim 43, characterised in that it consists of an extruded or pultruded flexible profile, arranged to be placed on and along the flange surface (111), and arranged to splice together the two free ends.

48. Profile moulding (150) according to claim 43, characterised in that it is made up of a stiff or flexible profiled whole ring, arranged to be placed on the flange surface (111).

49. Profile moulding (150) according to claim characterised in that the profile moulding (150) includes longitudinal recesses (114') at the ends, arranged to receive straight or, in the flange area, kinked joints (114b) arranged to splice the profile moulding so as to adjust it to the profile of the mould's (1) flange (110).

50. Procedure for forming a vacuum bag (2) with seal flange (120) with contact surface (121) arranged to bear against a flange surface (121) of a flange (110) on a mould (1), designed for moulding composite materials (9), characterised by

the placement of a profile moulding (150) on the mould's (1) flange surface (111), where the profile moulding (150) has been arranged to constitute a form for moulding the contact surface (121) of the of the profiled seal flange (120), where the profile moulding has a top surface (121'), a (first), inner longitudinal furrow (143') in the top surface (121'), designed to form a (first), inner seal (143) as an elevation in the contact surface (121), and to form a vacuum canal (155) inside of first, inner seal (143);

the adding of a preferably liquid seal/vacuum bag mass (158) into the groove (143'), on to the top surface (121') and into the mould (1) so that an integrated vacuum bag (2) is formed, which covers the entire mould's (1) casting surface and flange surface (111);

solidification/tempering of the integrated vacuum bag comprising the seal/vacuum mass (158) in a per se familiar way, until the vacuum bag (2) has obtained sufficient tensile strength and/or mechanical strength to be released from the mould (1).

51. Procedure according to claim 50, characterised by that a heat-resistant and elastic material that retains its form after stretching is employed for the integrated vacuum bag (2) and the seal flange (120), preferably silicone.

52. Procedure according to claim 50, characterised by that, prior to adding the seal/vacuum bag mass (158), a stiffening profile (114) for the seal flange (120) is placed at a desired distance over the profile moulding (150).

53. Procedure according to claim 50, characterised by the placement of reinforcement supports (117) on the profile moulding for supporting the stiffening profile (114) during the moulding of the seal flange (120), where the reinforcement supports (117) preferably

consist of the same type of material as the seal/vacuum mass (158) which will constitute the seal flange (120) and the vacuum bag (2).

54. Procedure according to claim 50, characterised in that the stiffening profile (114) is moulded in its entirety into the seal flange (120).

55. Procedure according to claims 50, 51 or 52, characterised by the placement of at least one valve sleeve (141) on the profile moulding (150), standing between the first, inner furrow (143') and the second, outer furrow (145') in the top surface (121') of the profile moulding (150).

56. Procedure according to claim 50, characterised by the adding of carbon fibre into the liquid seal/vacuum mass (158).

57. Procedure for moulding an outer layer in a composite material (9) by casting in a mould (1), characterised in that the mould (1) and preferably a release layer (30) are coated with a colour or structure layer (32) which is able to adhere to a fibre reinforcement (5) or a matrix material (8) for the purpose of moulding an integrated coloured and/or structured surface of the finished composite material (9).

58. Procedure according to claim 57, characterised by the electrostatic spraying on of a colour agent layer (32), where the colour agent and the mould (1) are given opposite electric charges during the spraying process.

59. Procedure according to claim 57, characterised by pre-heating of the mould (1) before adding the colour agent layer (32) so that the colour agent layer (32) is partially melted as soon as it is applied to the mould

(1).

60. Procedure according to claim 59, characterised by the cooling down of the colour agent layer (32) before adding any further components which are to be included in the composite material, like the matrix material and the fibre reinforcement (8,5,80).

61. Procedure according to claim 57, characterised by that the colour agent layer (32) is partially melted by means of heat, and preferably cooled down before adding the matrix material and fibre reinforcement (8,5,80).

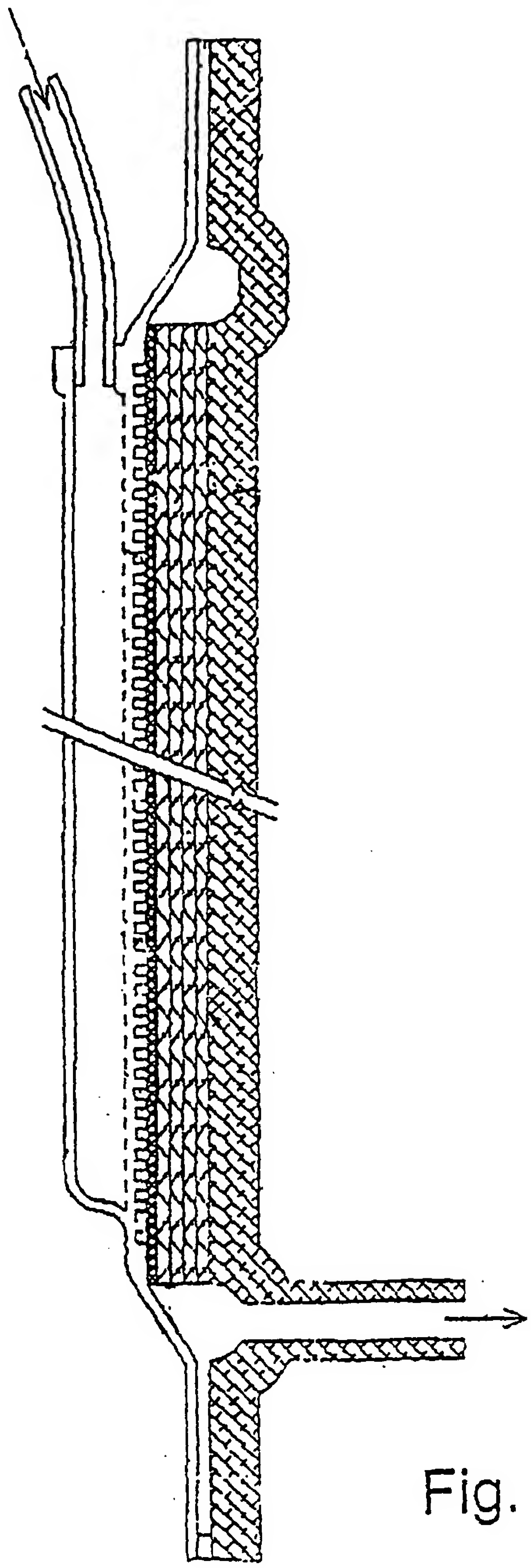


Fig. 1a

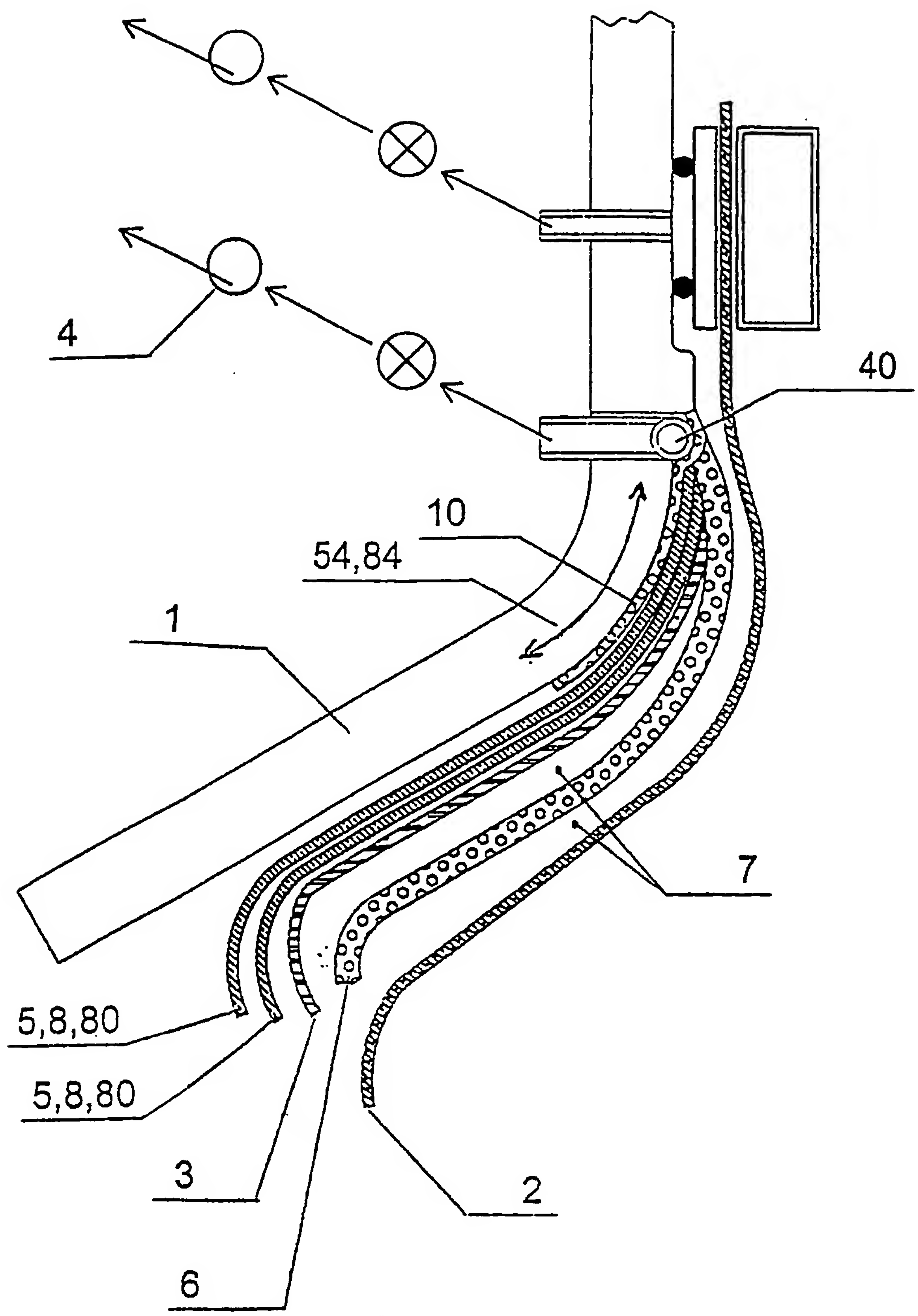


Fig. 1b

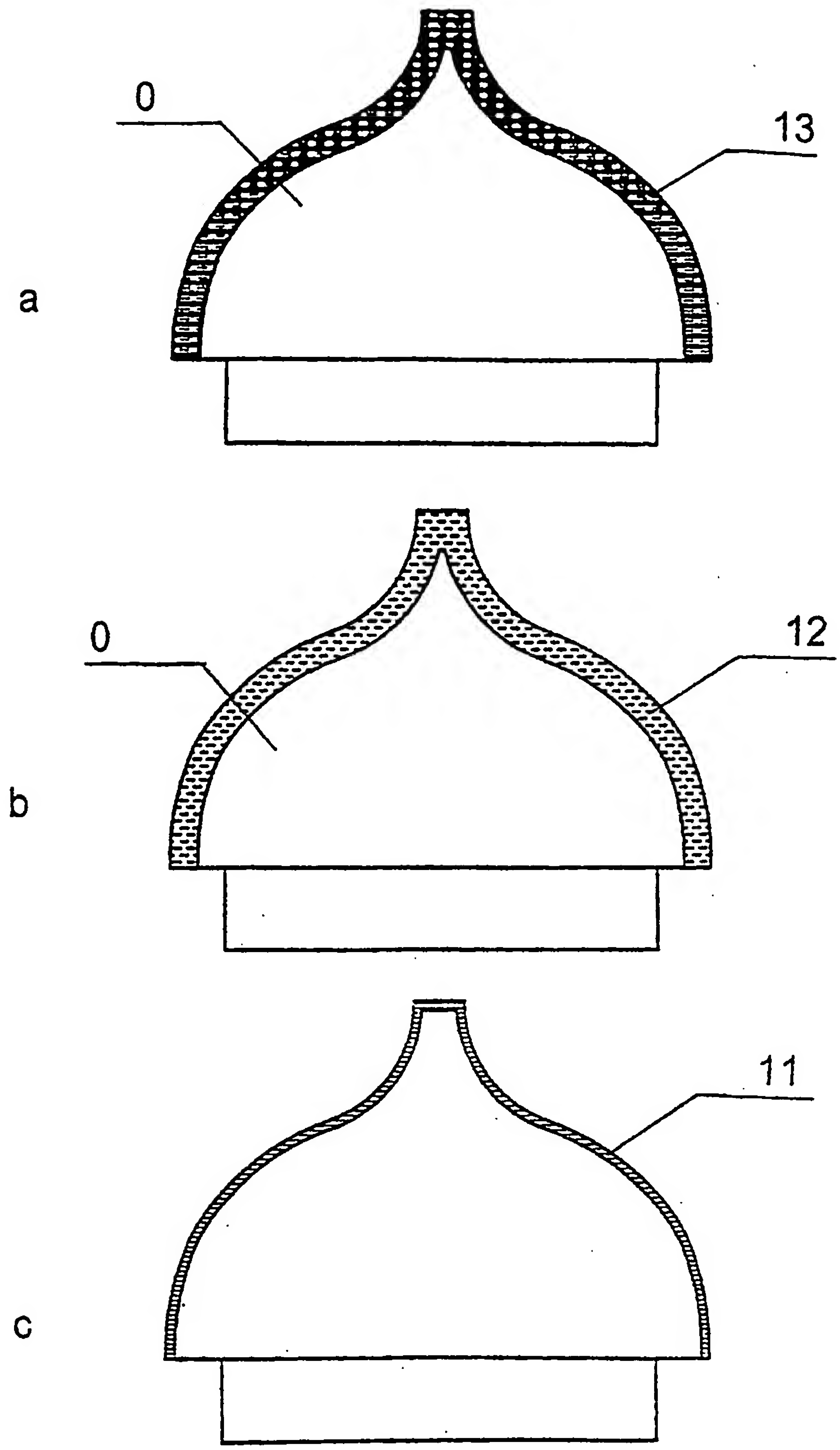


Fig. 2

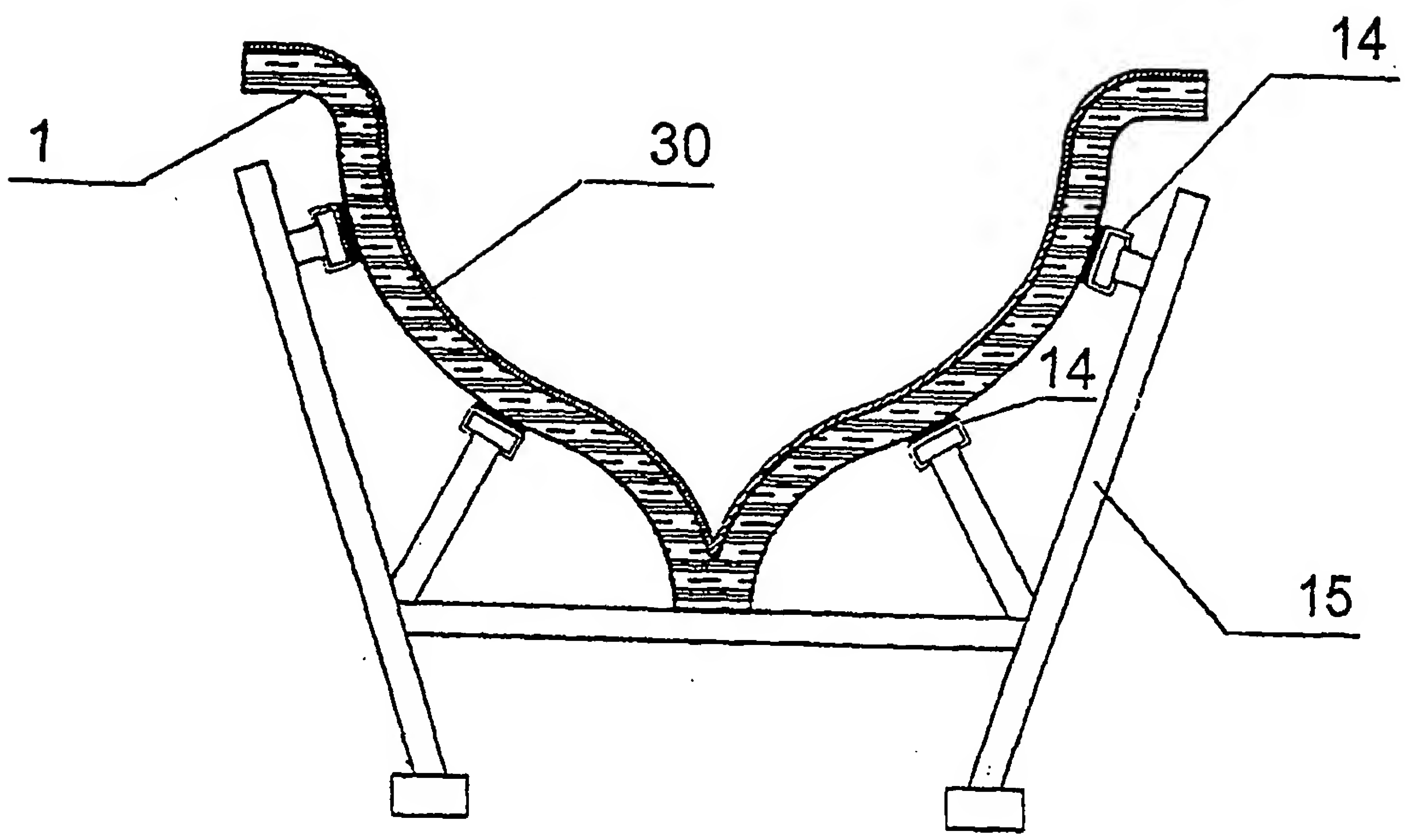
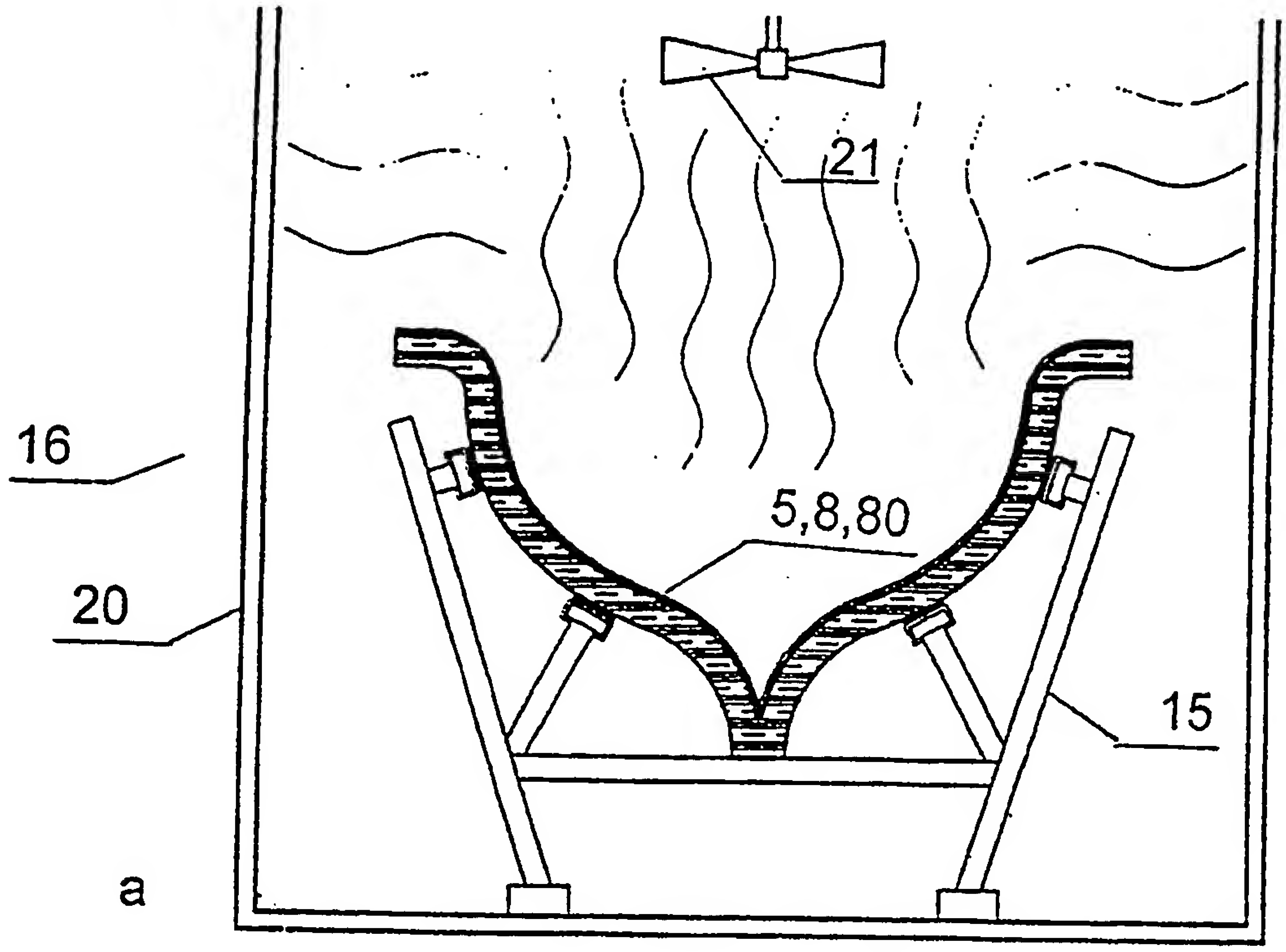


Fig. 3



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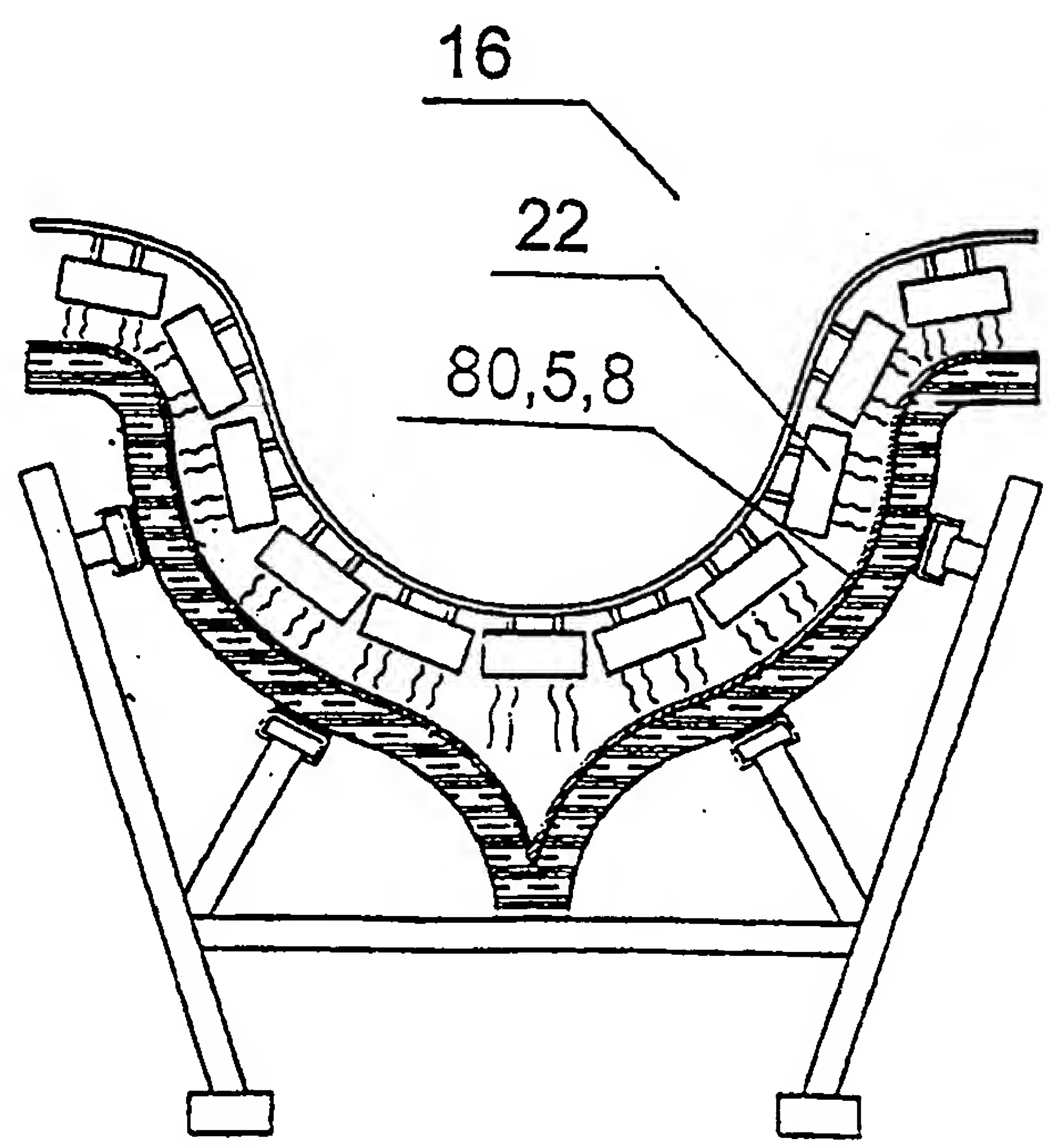
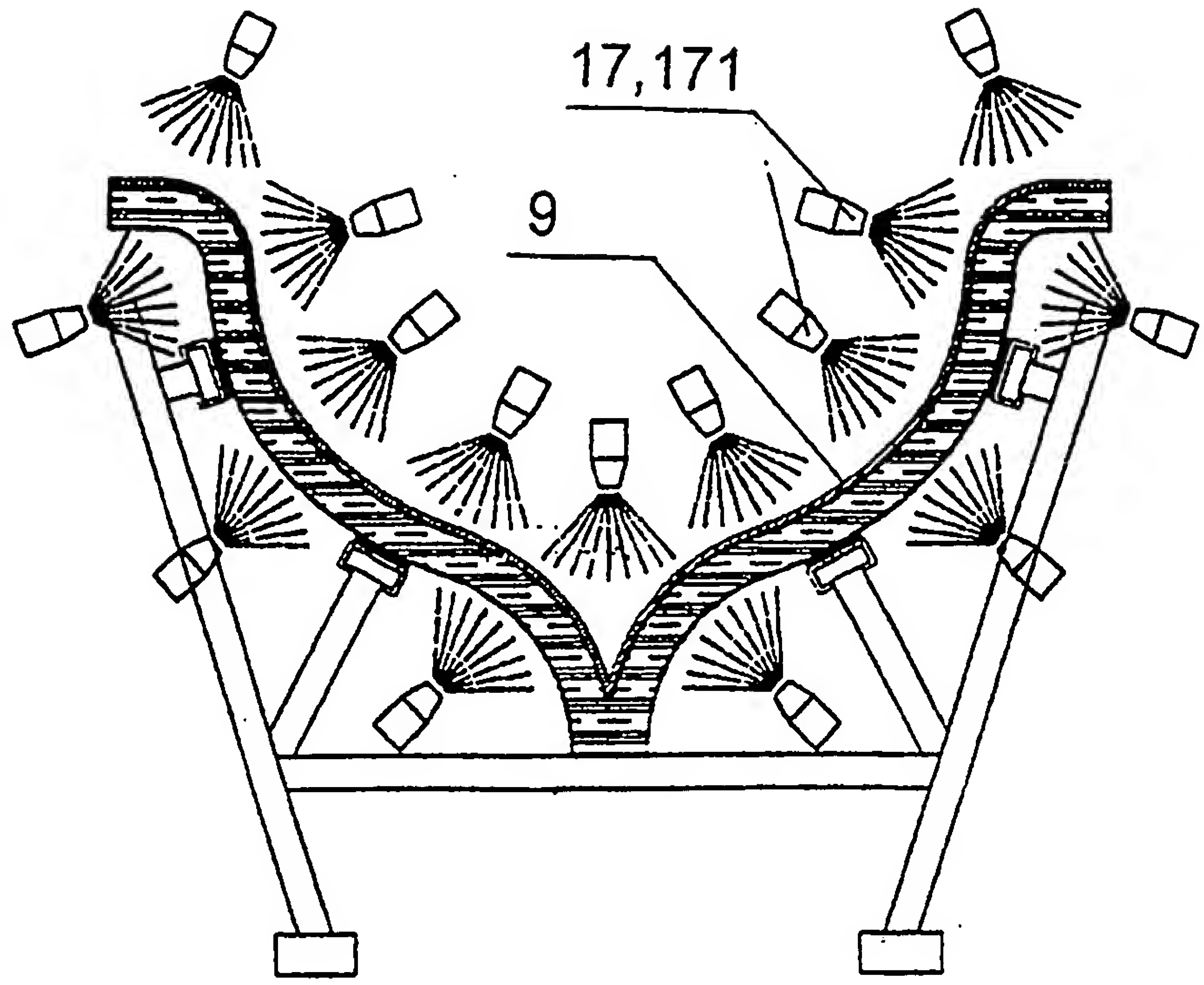


b

Fig. 4

a



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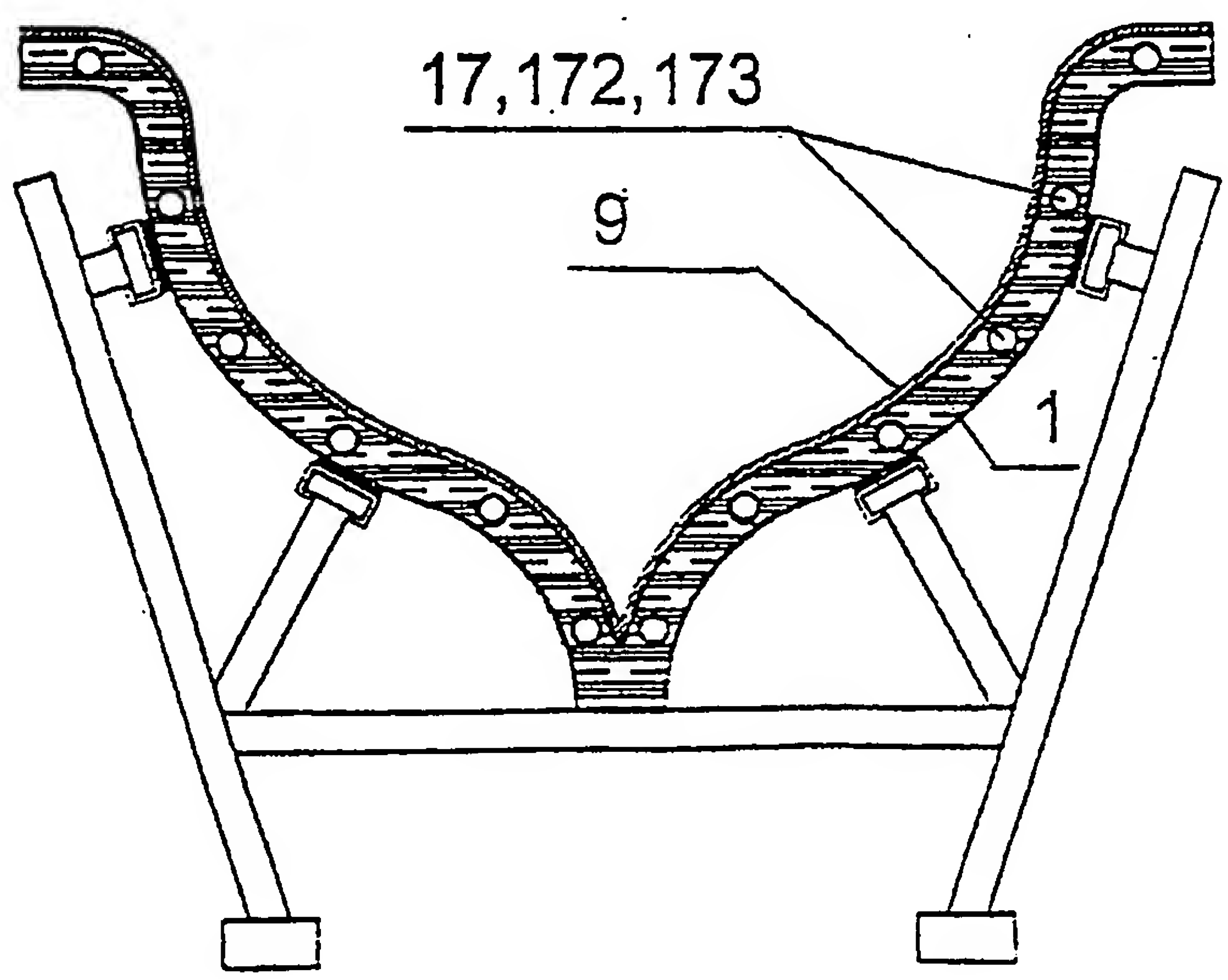


Fig. 5

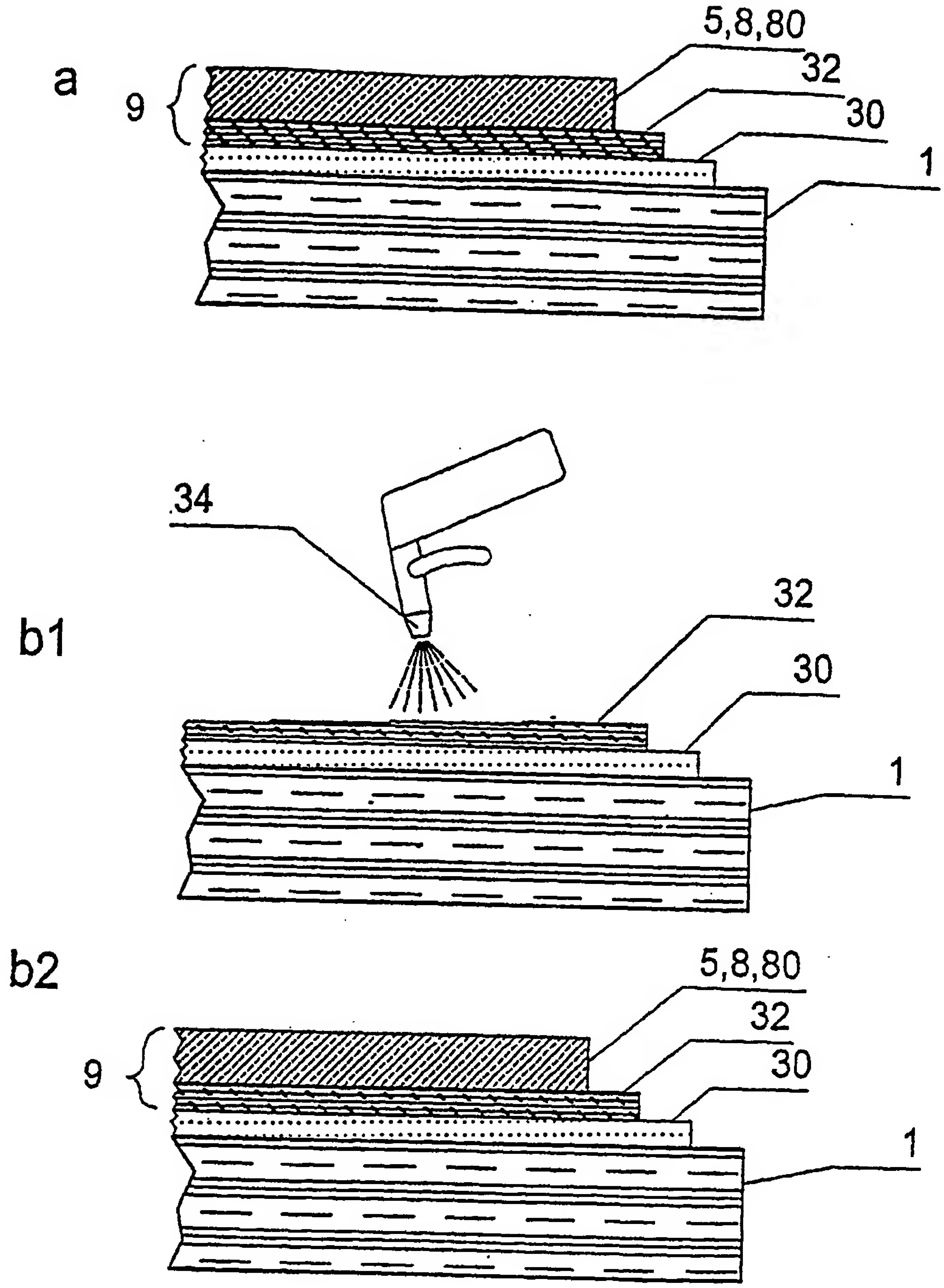


Fig.6

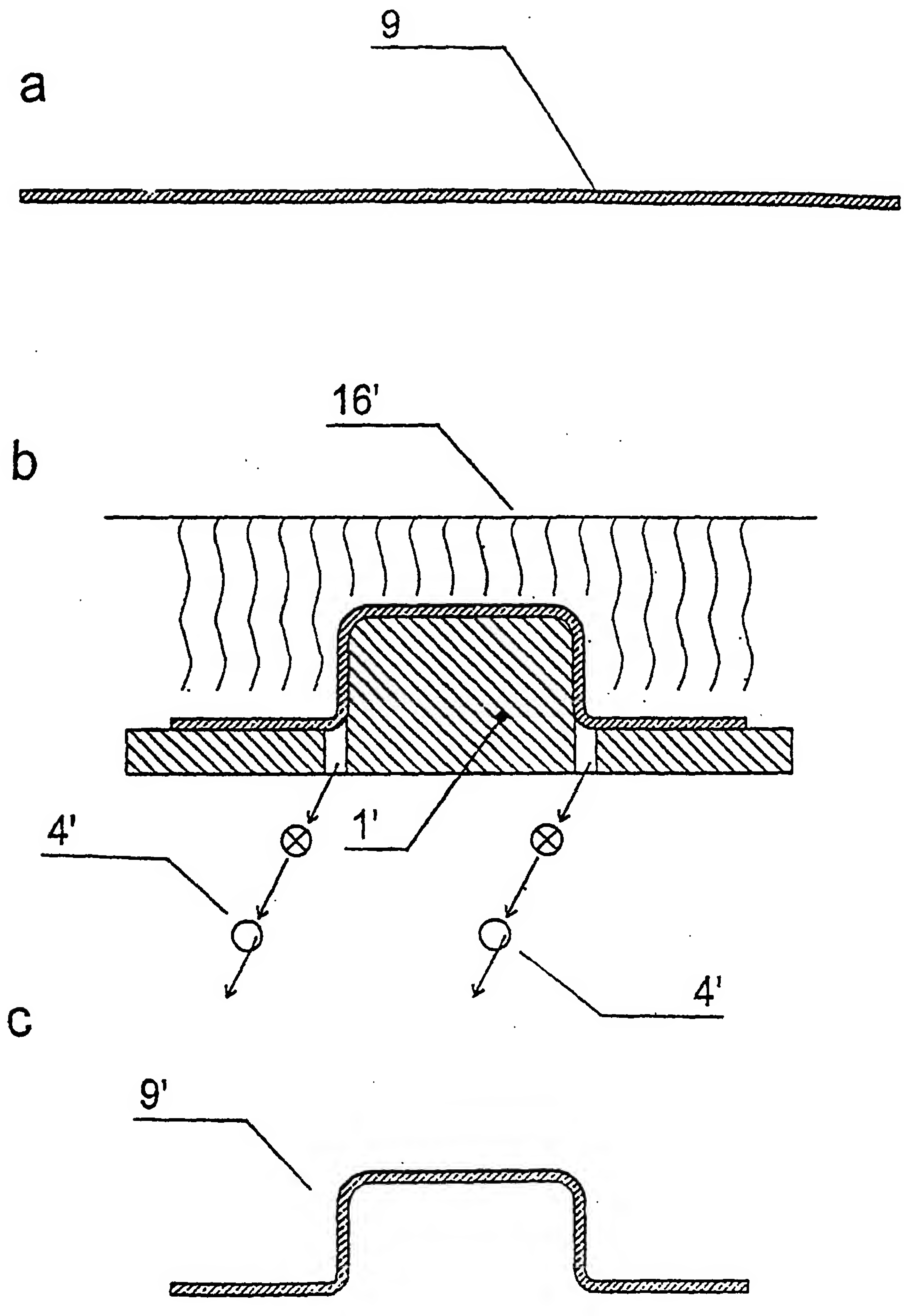
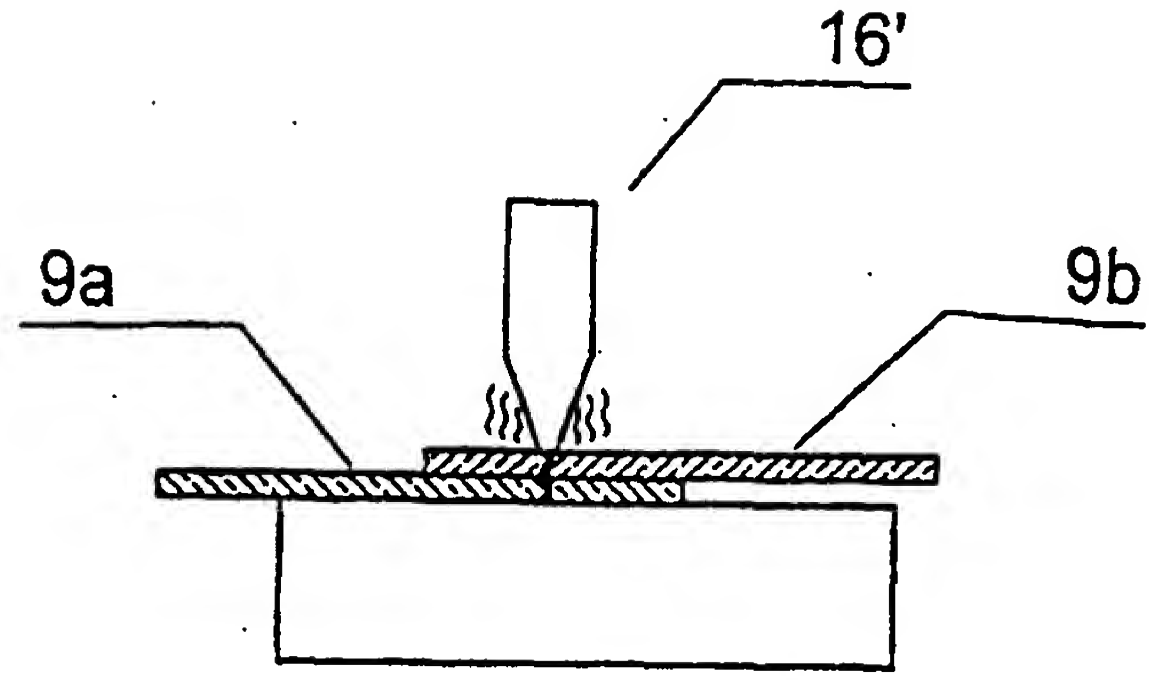


Fig. 7

a



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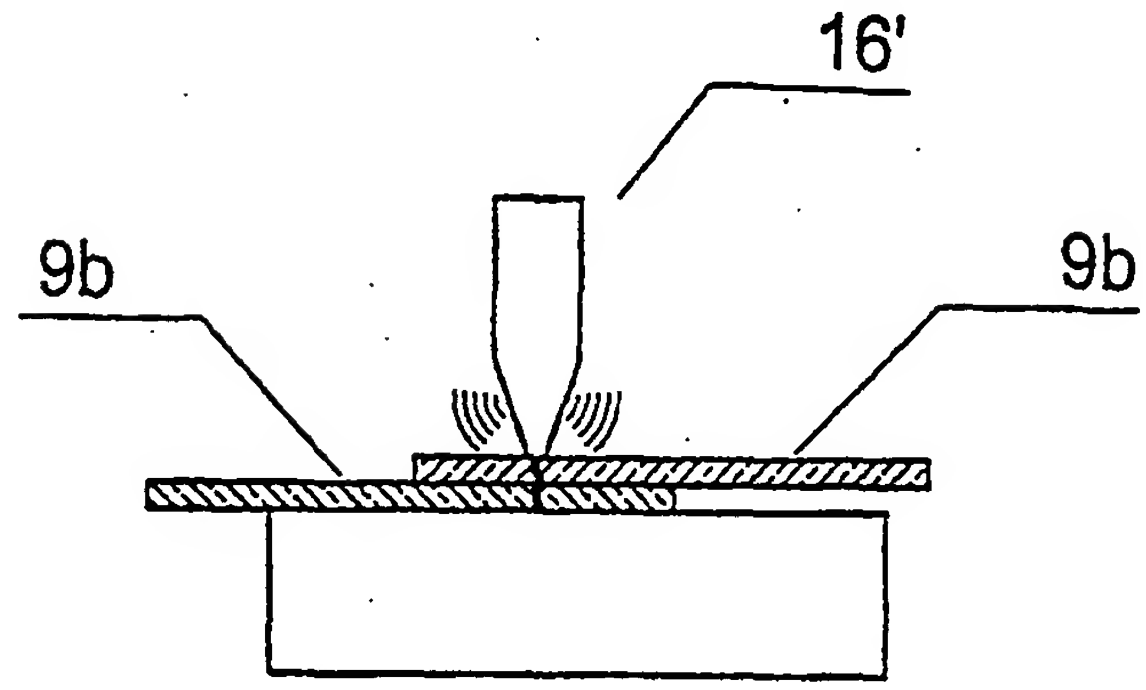


c

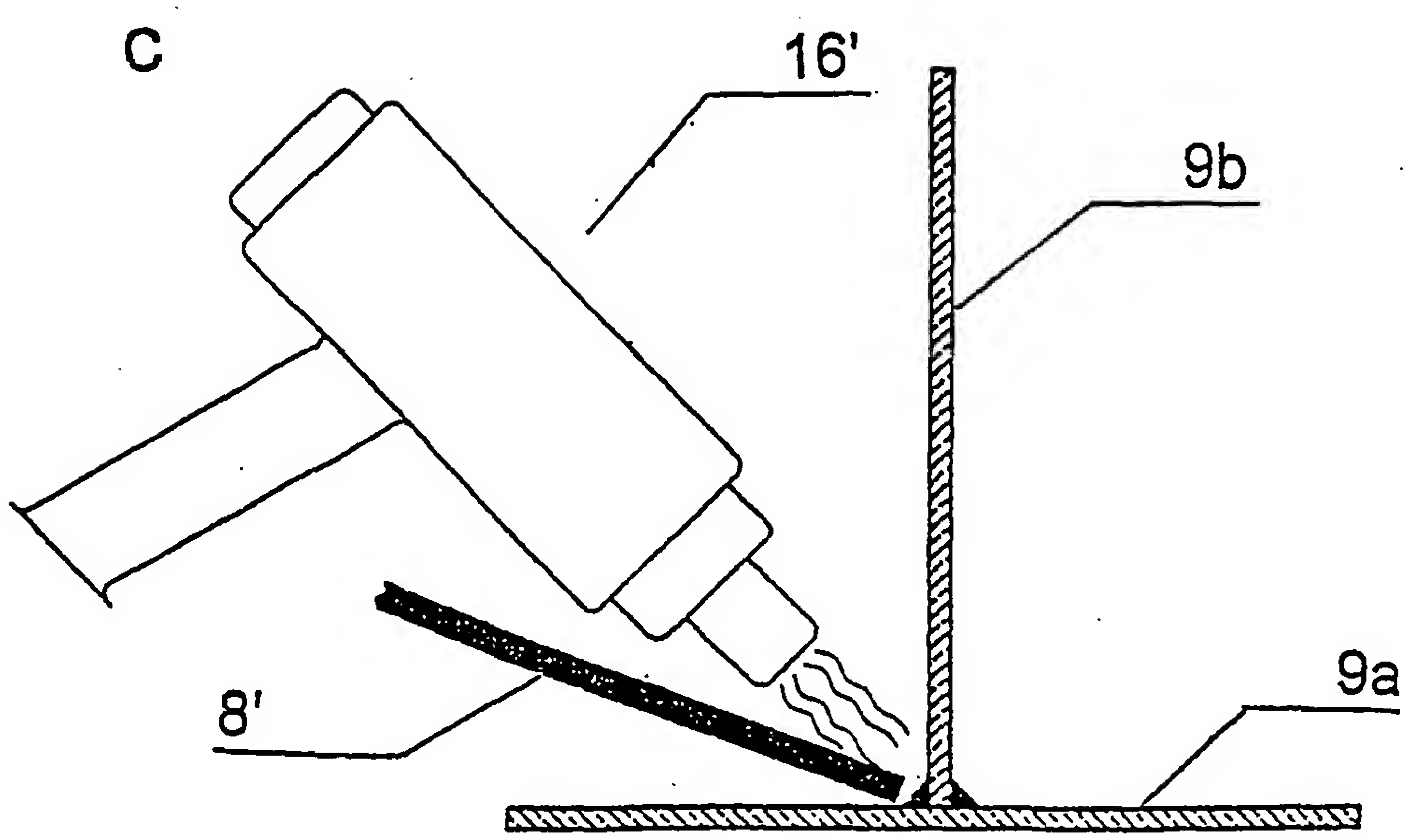


Fig. 8

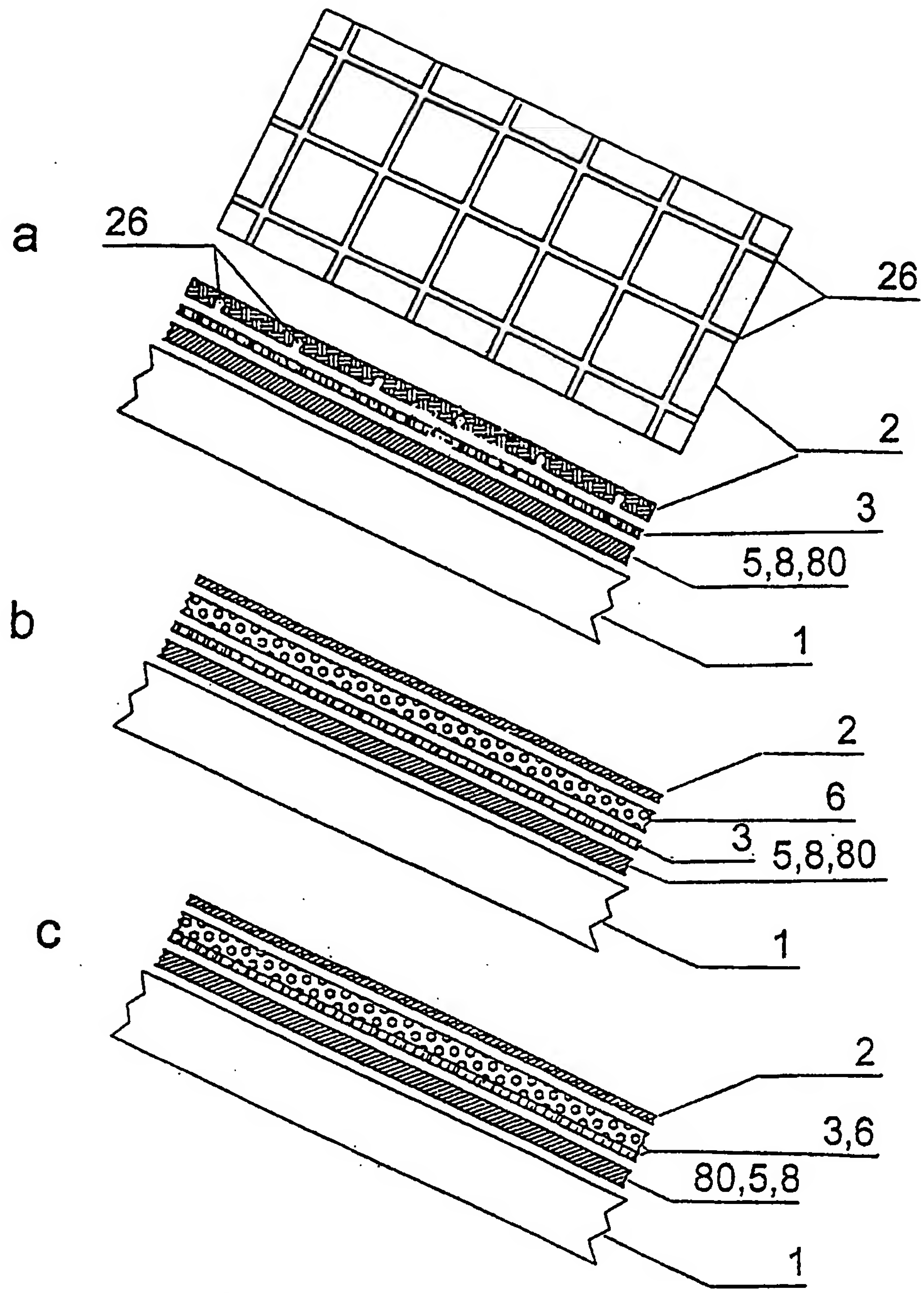
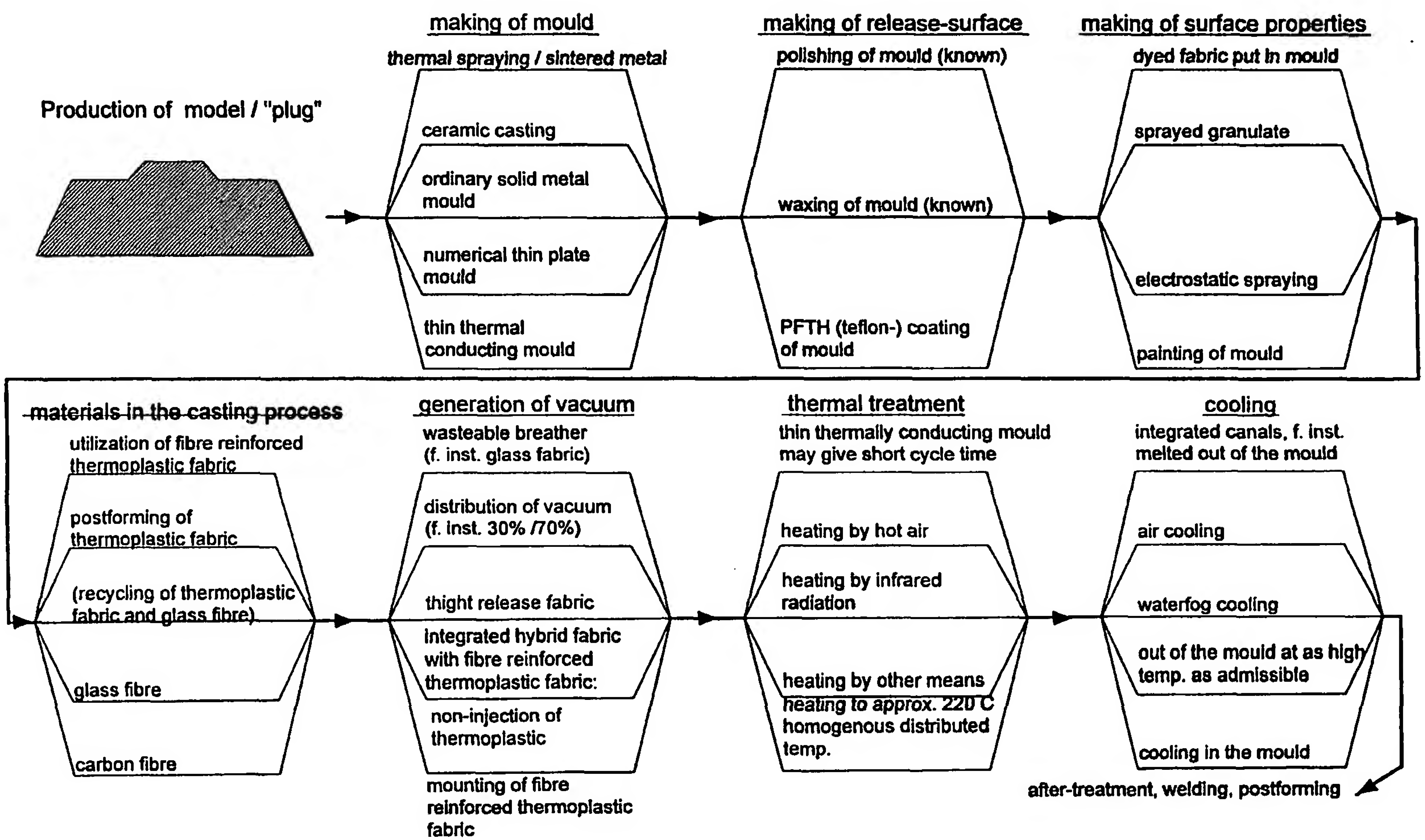


Fig. 9

Fig. 10: Overview of the thermoplastic process

Process for casting fibre reinforced thermoplastics



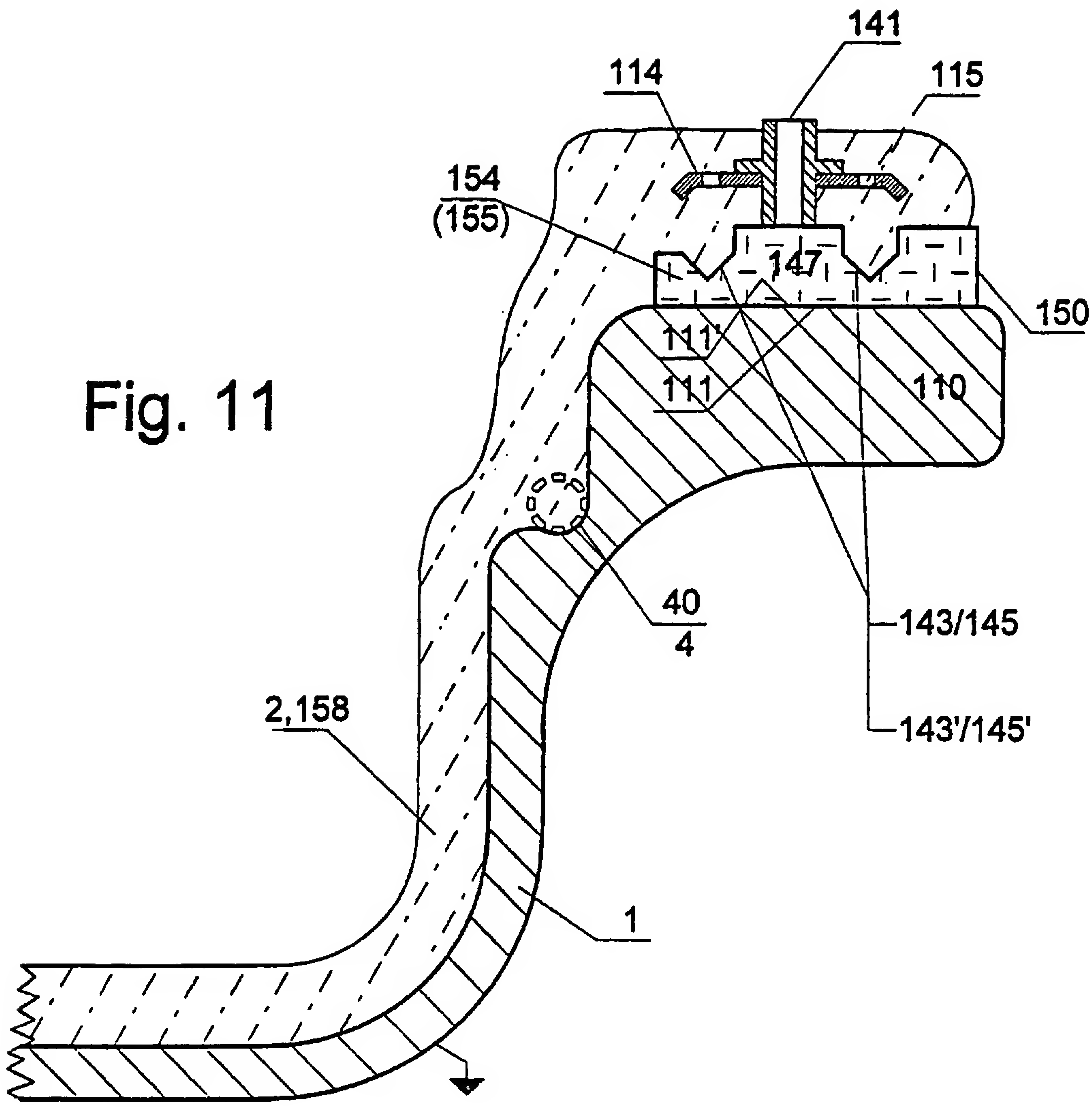

141
114
115
154
(155)
147
150
111'
111
110
40
4
143/145
143'/145'
2,158
1

Fig. 11

Fig. 12

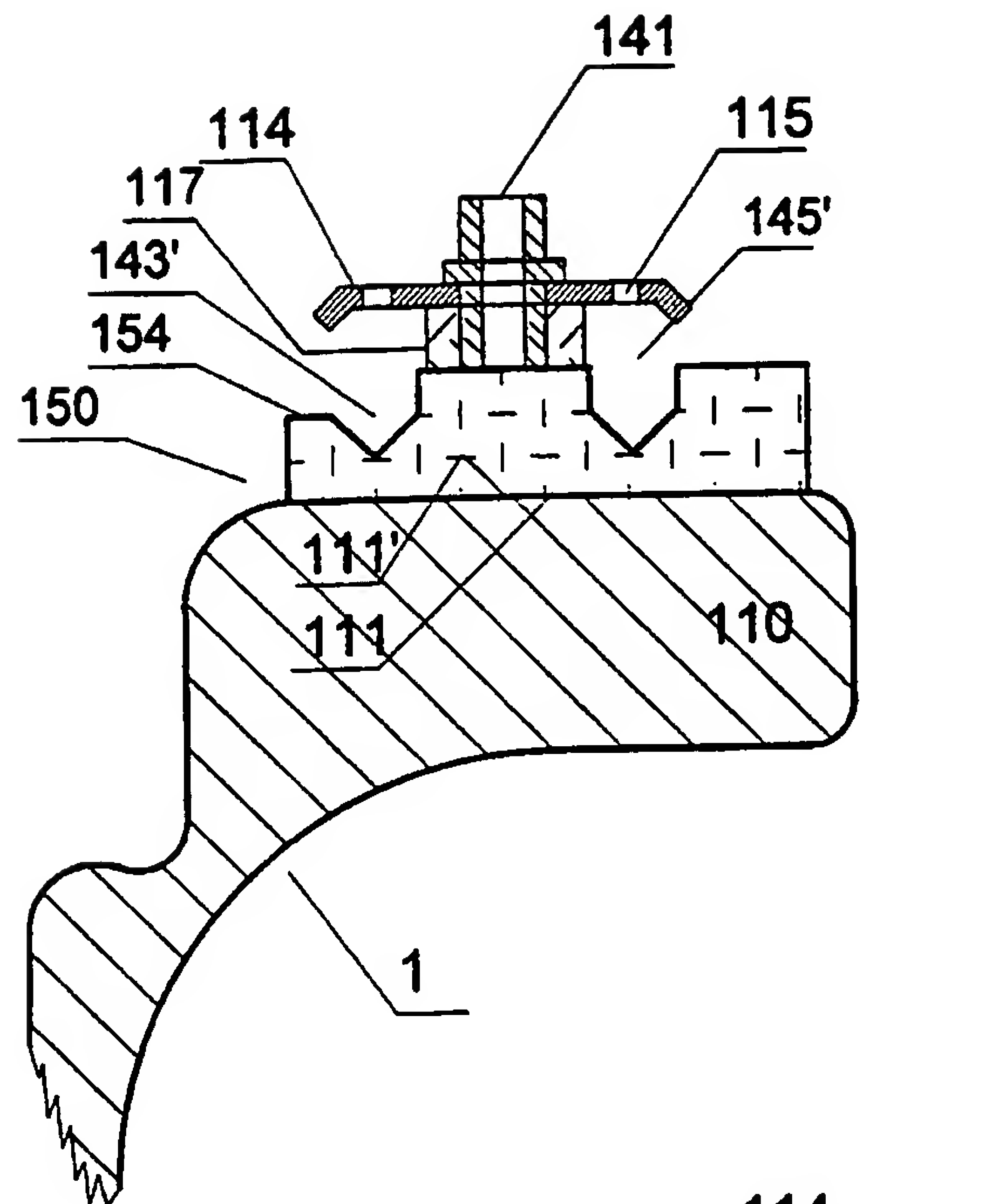


Fig. 12b

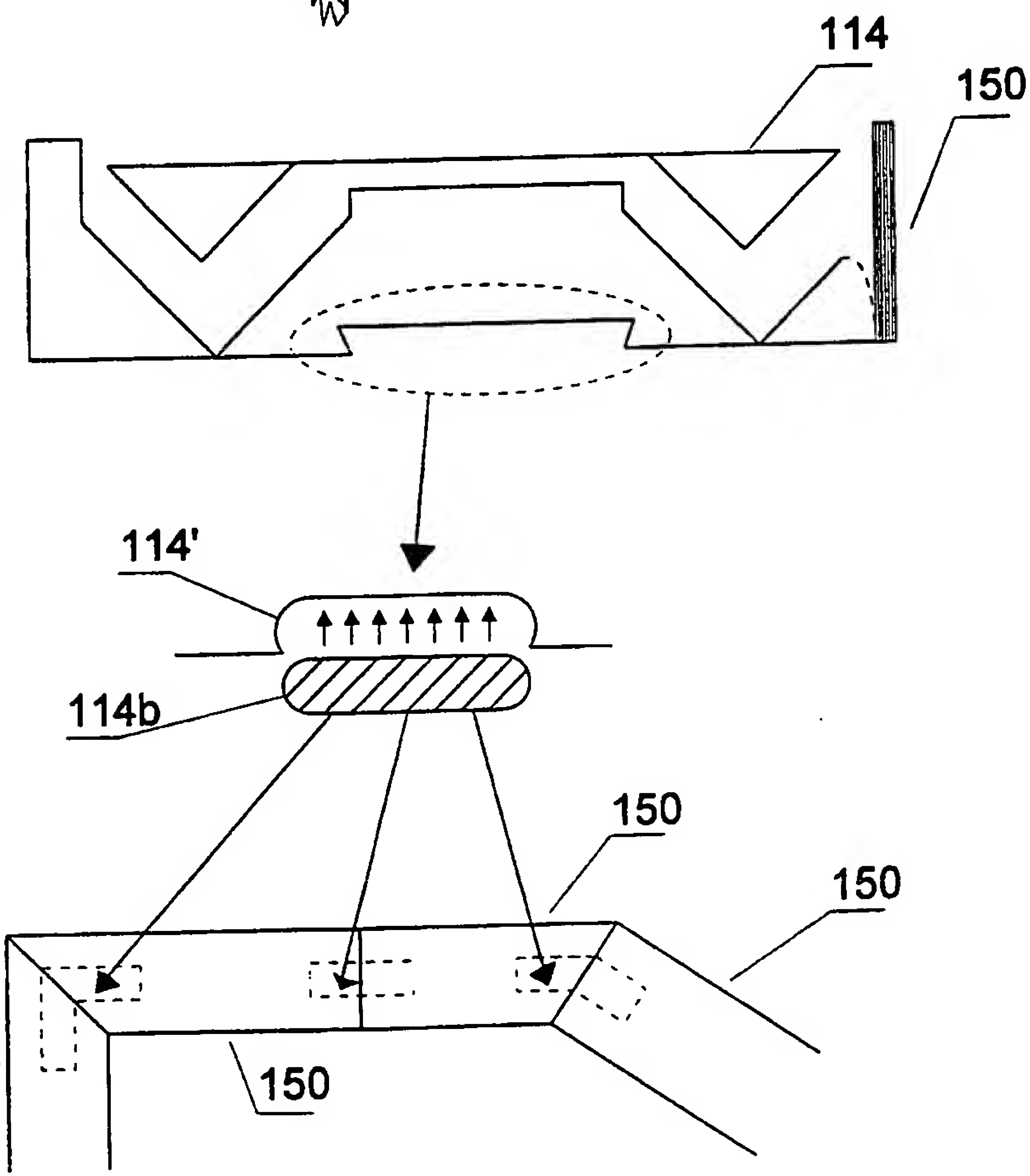


Fig. 13